THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EPE EVERYDAY PRACTICAL ELECTRONICS

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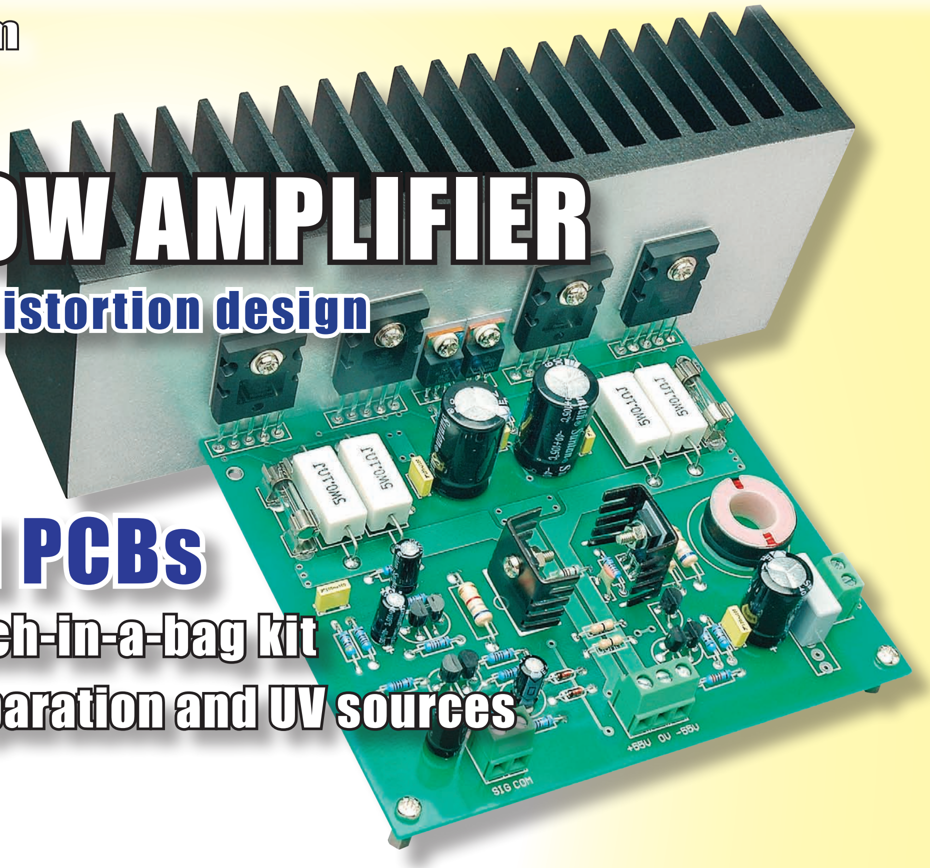


ULTRA-LD 200W AMPLIFIER

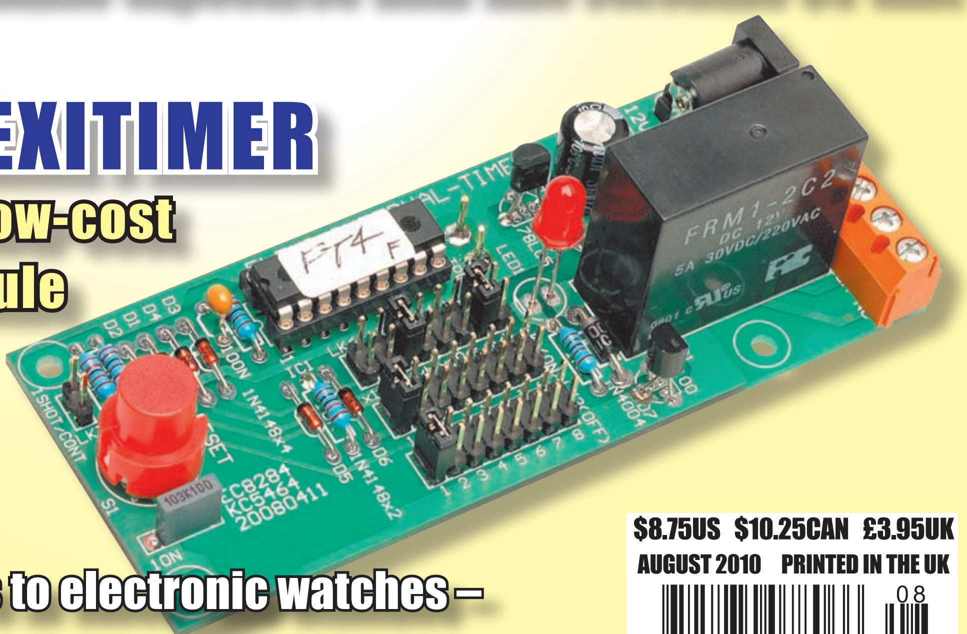
A new class-AB very low distortion design

MAKE YOUR OWN PCBs

- How to use the Seno etch-in-a-bag kit
- Top tips on design, preparation and UV sources
- Health & Safety advice

UV LIGHTBOX FOR MAKING PC BOARDS

Make high quality, reliable exposures with this versatile UV unit



PIC-BASED FLEXITIMER

Easily programmed, low-cost electronic timer module

Plus

RECYCLE IT!

Fitting your own batteries to electronic watches – save a fortune with DIY!

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AUGUST 2010 PRINTED IN THE UK
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Velleman Kits

K1803	Universal Mono Pre-Amplifier Kit	4.34
K1823	1A Power Supply Kit	6.95
K2543	Electronic Transistor Ignition Kit	11.30
K2570	Universal 5 - 14VDC Power Supply Kit	9.42
K2572	Universal Stereo Pre-Amplifier Kit	7.95
K2573	Stereo Pre-Amplifier for MD Pick-Ups Kit	8.00
K2579	Universal Stop/Start Timer Kit	6.76
K2599	Windshield Wiper or Interval Timer Kit	10.90
K2601	Stroboscope Kit	13.14
K2604	Police Siren Kit	8.12
K2622	AM/FM Antenna Amplifier Kit	9.32
K2625	Digital Tachometer Kit	23.64
K2633	Relay Card Kit	14.28
K2634	Quad Triac Switch Card Kit	13.36
K2636	Speed Controller Kit	16.23
K2639	Liquid level Controller Kit	12.69
K2644	Frost Indicator Kit	8.31
K2649	Thermostat with LCD Kit	32.73
K2651	LCD Panel Meter Kit	19.31
K2655	Electronic Watchdog Kit	22.13
K2661	Dual Input Amplifier Module Kit	16.55
K3400	Dual Electronic Dice Kit	10.91
K3500	Multifunction car Courtesy Light Kit	10.01
K3502	Parking Radar Kit	27.35
K3504	Car Alarm Kit	13.41
K3505	Car Light Warning Alarm Kit	9.18
K4001	7W Mono Amplifier Kit	6.90
K4003	2 x 30W Audio Power Amplifier Kit	16.96
K4004B	200W Mono/Stereo Amplifier Kit	46.25
K4005B	400W Mono/Stereo Amplifier Kit	62.85
K4006	Power Supply for K4004B and K4005B Kit	10.45
K4010	300W Mono Mosfet Amplifier Kit	138.19
K4040	Stereo Valve Amplifier/Chrome Kit	765.92
K4040B	Stereo Valve Amplifier/Black Kit	809.94
K4102	Guitar Preamp with Headphone Output	19.85
K4301	Pink Noise Generator Kit	8.31
K4304	Mono VU Meter 10 LEDs Kit	9.95
K4305	Stereo VU Meter 2 x 10 LEDs Kit	15.95
K4306	Precision Stereo VU Meter 2 x 15 LEDs Kit	24.95
K4307	Audio Power Meter Kit	15.35
K4401	Sound Generator Kit	15.95
K4600	Video and RGB Converter/Processor Kit	95.61
K4601	Audio/Video TV Modulator Kit	25.89
K4700	2-Channel Loudspeaker Protection Kit	13.70
K4701	Loudspeaker DC-Protection Kit	10.00
K4900	Telephone Amplifier Kit	8.50
K5200	4-Channel Multi-Function Running Light Kit	18.08
K5201	Light Computer Kit	29.94
K5203	Dual Function Strobe Kit	18.29
K5600R	Advertisement LED Display (Red) Kit	42.63
K6001	Temperature Sensor (for K6002) Kit	13.75
K6002	Temperature Controller Kit	50.11
K6003	Temperature Sensor with LED Display Kit	46.40
K6200	0 to 60 Hours Start/Stop Timer Kit	12.17
K6400	Code Lock Kit	20.37
K6501	Remote Control by Telephone Kit	38.22
K6600	Multitone Chime Kit	11.95
K6712	IR Remote Controlled Dimmer Kit	29.15
K6714	Universal Relay Card (8 Relay's) Kit	36.34
K6714-16	Universal Relay Card (16 Relay's) Kit	51.79
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K7101	Mains Voltage Detector Kit	7.07
K7102	Metal Detector Kit	7.62
K7105	Handheld LCD Osciloscope Kit	135.28
K7203	3-30V 3A Power Supply Kit	25.10
K7300	Universal Battery Charger/Discharger Kit	13.84
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K8005	Stepper Motor Card Kit	25.90
K8006	Domotica Light System - Busprint Kit	25.52
K8008	Multifunction Relay Module Kit	12.90
K8009	Multifunctional Clock Kit	53.10
K8011	Mono 95W Valve Power Amplifier Kit	345.90
K8012	Lead Acid Battery Charger/Conditioner	27.98
K8015	Multifunction Relay Switch Kit	14.94
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K8017	3-Channel Sound Light with Microphone	33.80
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K8021	High-End Control Amplifier Kit	155.37
K8023	10-Channel, 2-Wire Remote Control Kit	24.41
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K8027	Relay Output Module (for K8006) Kit	9.95
K8028	Multifunction Dimmer Kit	22.20
K8029	Slow On-Off Dimmer Kit	13.60
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K8032	4 channel Running Light Kit	20.58
K8033	Power Blinker Kit	13.04
K8035	Multifunctional Up/Down Counter Kit	17.85
K8036	Video Signal Cleaner Kit	20.58
K8037	Bus Dimmer for Home Light System Kit	12.70
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K8039	1 Channel DMX Controlled Power Dimmer	29.95
K8040	High-End MOSFET Power Amplifier Kit	181.45
K8041	Fan Timer Kit	10.57
K8042	Symmetric 1A Power Supply Kit	7.78
K8044	12V 10-Channel Light Effect Generator Kit	21.44
K8045	Programmable Message Board with LCD	32.92
K8046	User-Definable 8-Channel Touch Panel Kit	40.63
K8047	4-Channel Recorder/Logger Kit	29.01
K8048	PIC Programmer and Experiment Board	24.65
K8049	15-Channel IR Transmitter Kit	25.73
K8050	15-Channel IR Receiver Kit	18.38
K8051	15-Channel IR Remote Stick Kit	14.35
K8055	USB Experiment Interface Board Kit	24.80
K8056	8-Channel Relay Card Kit	30.45
K8057	2-Channel RF Remote Receiver	17.19
K8058	8-Channel RF Remote Control Kit	25.73
K8059	2-Channel RF Code-Lock Transmitter Kit	11.52
K8060	Discrete Power Amplifier 200W Kit	12.85
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K8062	USB Controlled DMX Interface Kit	47.90
K8063	2 Modular Lights with Serial Interface Kit	21.60
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K8065	Pocket Audio Generator Kit	13.41
K8066	3W Mono Amplifier Kit	6.86
K8067	Universal Temperature Sensor Kit	10.82
K8068	Dimmer for Electronic Transformers Kit	13.98
K8070	1-Channel RF Receiver (for K8058) Kit	16.85
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K8075	Power Saver/Timer Kit	11.52
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K8084	Volume & Tone Control Pre-Amplifier Kit	13.60
K8086	Telephone Ring Detector & Relay Output	11.08
K8087	Telephone Ring with Buzzer and LED Kit	10.83
K8088	RGB Controller Kit	15.15
K8089	Big Digital Clock, Temp Display Kit	40.75
K8090	8 Channel USB Relay Card Kit	39.95
K8091	LED Clock with Light Dimmer Function Kit	22.49
K8092	Optical proximity switch Kit	17.45
K8095	SD/MICRO SD MP3 Player Kit	39.99
K8098	Audio Analyser Kit	31.65
K8099	Nixie Clock Kit	64.96
K8100	Video Digitiser Card for PC Kit	113.69

Velleman Mini Kits

MK100	Electronic Christmas Tree Minikit	5.63
MK101	Flashing LED Sweetheart Minikit	6.25
MK102	Flashing LED's Minikit	2.99
MK103	Sound to Light Minikit	4.21
MK104	Electronic Cricket Minikit	6.73
MK105	Signal Generator Minikit	4.21
MK106	Metronome Minikit	6.90
MK107	LED Running Light Minikit	4.75
MK108	Water Alarm Minikit	3.74
MK109	Electronic Dice Minikit	4.45
MK110	Simple One Channel Light Organ Minikit	5.84
MK111	Interval Timer Minikit	4.60
MK112	Brain Game Minikit	5.95
MK113	Siren Sound Generator Minikit	5.40
MK114	Low Voltage Light Organ Minikit	7.53
MK115	Pocket VU Meter Minikit	4.25
MK116	Riding Santa Minikit	12.45
MK117	Delux Xmas Tree Minikit	12.68
MK118	FM Radio Minikit	14.73
MK119	Roulette Minikit	11.82
MK120	Light Barrier Minikit	6.90
MK121PAL	Classic TV Game Minikit	10.70
MK122	Animated Bell with 83 LED's Minikit	8.25
MK123	Rolling Clock Minikit	14.79
MK124	Rolling Message Minikit	11.91
MK125	Light Sensitive Switch Minikit	3.95
MK126	Car Alarm Simulator Minikit	4.22
MK127	Running Microbug Minikit	9.02
MK128	Kitchen Timer Minikit	11.55
MK129	Crawling Microbug Minikit	11.48
MK130	3D Xmas Tree Minikit	7.69
MK131	Traffic Light Minikit	6.85
MK132	Cable Polarity Checker Minikit	5.05
MK133	Quiz Table Minikit	6.85
MK134	Steam Engine Sound Generator Minikit	7.47
MK135	Electronic Decision Maker Minikit	3.38
MK136	Super Stereo Ear Minikit	7.44
MK137	IR Remote Checker Minikit	4.43
MK138	Thermostat Minikit	4.95
MK139	Clap On/Off Switch Minikit	10.80
MK140	Karaoke Minikit	8.67
MK141	SMD Happy Face Minikit	4.17
MK142	SMD Xmas Tree Minikit	5.29
MK143	White LED Flashlight Minikit	7.07
MK144	Flashing Heart Minikit	5.29
MK145	Halloween Pumpkin Minikit	7.63
MK146	Pocket VU Meter Minikit (with Enclosure)	7.44
MK147	Dual White LED Stroboscope Minikit	5.20
MK148	Dual Super Bright Flashing Red Lights	4.43
MK149	Love Tester Minikit	11.15
MK150	Shaking Dice Minikit	8.49
MK151	Digital LED Clock Minikit	15.09
MK152	Wheel of Fortune Minikit	3.95
MK153	Jumbo Single Digit Clock Minikit	12.53
MK154	5 in 1 Emergency Tool Minikit	11.84
MK155	Magic Message Minikit	11.84
MK157	LCD Mini Message Board Minikit	15.96
MK158	LCD Mini Message Board with Backlight	21.14
MK159	Brain Game Minikit	10.47
MK160	Remote Control via GSM Mobile Phone	8.93
MK161	2-Channel IR Remote Receiver Minikit	9.95
MK162	2-Channel IR Remote Transmitter Minikit	8.49
MK163	Electronic Stereo Volume Control Minikit	10.90
MK164	IR Electronic Volume Control Minikit	14.79
MK165	Crawling Bug Minikit	13.89
MK166	Animated Ghost Minikit	9.09
MK167	Electronic Candle Minikit	3.81
MK168	Alarm Sensor Simulator Minikit	5.95
MK169R	Flashing LED Star (Red) Minikit	6.20
MK169Y	Flashing LED Star (Yellow) Minikit	6.20
MK170	60 LED Multi-Effect Star Minikit	10.98
MK171	Voice Changer Minikit	6.71
MK172	Sound LED Star Minikit	7.83
MK173	Mini 6-LED Chaser Minikit	8.50
MK174	Single-Message Record/Playback Minikit	11.87
MK175	Animated LED Smiley Minikit	7.45
MK176	LED Chevron Arrow Minikit	8.49
MK177	Ding Dong Minikit	4.90
MK178	3rd Brake Light Flasher Minikit	6.30
MK179	Proximity Card reader Minikit	14.25
MK180	2 Channel Hi-power LED Flasher Minikit	10.50
MK181	AC Power voltage indicator LED Minikit	2.43
MK182	Digital Echo Chamber Minikit	11.43

Velleman Modules - Assembled

VM100	200W Power Amplifier Module	38.54
VM101	Multifunctional Dimmer Module	34.90
VM103	Blinking Module	34.43
VM105	AC Power Slave Module	34.43
VM106	Video Signal Cleaner Module	30.44
VM107	Multifunctional Counter Module	38.91
VM110	USB Interface Card Module	34.90
VM111	PIC Programmer and Experiment Module	32.60
VM112	Personal Animated Badge Module	19.95
VM113	Stereo Amplifier Module 2 x 30W	19.25
VM114	7W Mono Audio Amplifier Module	7.95
VM116	USB Controlled DMX Interface Module	67.15
VM118	8-Channel RF Remote Control Set Module	68.77
VM118R	8-Channel RF Remote Transmitter Module	36.02
VM119	One Channel Dual Output Receiver	19.40
VM120	10-Channel Light Effect Generator	32.02
VM121	15-Channel Infrared Transmitter Module	36.02
VM122	15-Channel Infrared Receiver Module	29.62
VM124	1A Power Supply Module	6.50
VM125	Ultrasonic Radar Module	26.54
VM129	8-Channel Relay Card Module	33.29
VM130	2-Channel RF Remote Control Set Module	35.45
VM130T	2-Channel RF Remote Control Transmitter	12.90
VM131	Dimmer for Electronic Transformers	24.04
VM132	Universal Temperature Sensor Module	13.04
VM133	Energy Saver Module	18.15
VM134	PIC Programmer Board Module	36.90
VM135	Magical Dimmer Module	13.58
VM136	Interval Timer Module	6.30
VM137	Thermostat Module 5° - 30°C Module	7.95
VM138	DMX Controlled Relay Module	21.74
VM139	IR Remote Checker Module	7.64
VM140	Extender USB Interface Board Module	79.95
VM141	Start/Stop Timer Module	12.95
VM142	Mini-Pic Application Module	26.00
VM143/1W	1W High Power LED Driver Module	9.85
VM143/3W	3W High Power LED Driver Module	9.95
VM144	Telephone Ring Detector & Relay output	14.65
VM145	Digital Panel Thermometer Min/Max	23.35
VM146	RGB Controller Module	22.52
VM147	Panel Counter Module	23.35
VM148	Panel Thermostat Module	26.80
VM150	RGB LED Dimmer for DIN rail *(Due July)*	31.00
VM151	RGB Controller Module & remote control	26.35
VM152	LED Dimmer with RF Remote Control	29.53
VM154	Fan Timer Module	17.55
VM156	Pocket Audio Generator Module	20.00
VM160	4 Channel RF Remote Control Set	47.50
VM160DT	4 Channel RF Desktop Transmitter	46.28
VM160T	4 Channel RF Replacement transmitter	17.05
VM161	RGB LED Strip Colour controller Module	22.75
VM162	RGB LED Strip Colour dimmer Module	30.86
VM163	Panel Clock Module	25.17
VM164	Mini Dimmer, Push button control *(Due July)*	14.78
VM165	0-10V DC Controlled Dimmer *(Due June)*	48.95
VM179	Proximity Card Reader Module	25.65
VM8090	8 Channel USB Relay Card *(Due July)*	58.40

Over 300 Kits, Mini Kits & Modules - check web site for details

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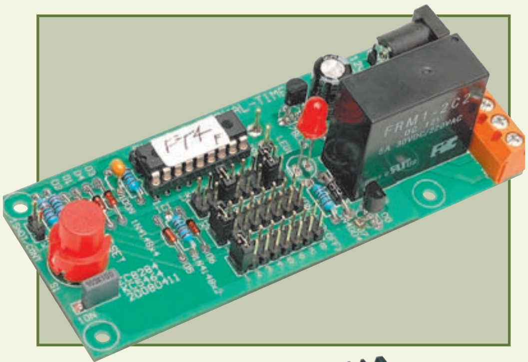

Projects and Circuits

Series and Features

Regulars and Services

Our September 2010 issue will be published on Thursday 12 August 2010, see page 72 for details.

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PIC & ATMEL Programmers

We have a wide range of low cost PIC and ATMEL Programmers. Complete range and documentation available from our web site.

Programmer Accessories:
40-pin Wide ZIF socket (ZIF40W) £14.95
18Vdc Power supply (PSU120) £19.95
Leads: Parallel (LDC136) £3.95 / Serial (LDC441) £3.95 / USB (LDC644) £2.95

NEW! USB & Serial Port PIC Programmer

USB/Serial connection. Header cable for ICSP. Free Windows XP software. See website for PICs supported. ZIF Socket and USB lead extra. 18Vdc.
Kit Order Code: 3149EKT - **£49.95**
Assembled Order Code: AS3149E - **£59.95**
Assembled with ZIF socket Order Code: AS3149EZIF - **£74.95**

NEW! USB 'All-Flash' PIC Programmer

USB PIC programmer for all 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows XP Software. ZIF Socket and USB lead not incl.
Assembled Order Code: AS3128 - **£49.95**
Assembled with ZIF socket Order Code: AS3128ZIF - **£64.95**

ATMEL 89xxxx Programmer

Uses serial port and any standard terminal comms program. 4 LED's display the status. ZIF sockets not included. Supply: 16Vdc.
Kit Order Code: 3123KT - **£27.95**
Assembled Order Code: AS3123 - **£37.95**

Introduction to PIC Programming

Go from complete beginner to burning a PIC and writing code in no time! Includes 49 page step-by-step PDF Tutorial Manual, Programming Hardware (with LED test section), Win 3.11—XP Programming Software (Program, Read, Verify & Erase), and 1rewritable PIC16F84A that you can use with different code (4 detailed examples provided for you to learn from). PC parallel port.
Kit Order Code: 3081KT - **£16.95**
Assembled Order Code: AS3081 - **£24.95**

PIC Programmer Board

Low cost PIC programmer board supporting a wide range of Microchip® PIC™ microcontrollers. Requires PC serial port. Windows interface supplied.
Kit Order Code: K8076KT - **£39.95**

PIC Programmer & Experimenter Board

The PIC Programmer & Experimenter Board with test buttons and LED indicators to carry out educational experiments, such as the supplied programming examples. Includes a 16F627 Flash Microcontroller that can be reprogrammed up to 1000 times for experimenting at will. Software to compile and program your source code is included.
Kit Order Code: K8048KT - **£39.95**
Assembled Order Code: VM111 - **£59.95**

Controllers & Loggers

Here are just a few of the controller and data acquisition and control units we have. See website for full details. 12Vdc PSU for all units: Order Code PSU445 £7.95

USB Experiment Interface Board

5 digital input channels and 8 digital output channels plus two analogue inputs and two analogue outputs with 8 bit resolution.
Kit Order Code: K8055KT - **£38.95**
Assembled Order Code: VM110 - **£64.95**

Rolling Code 4-Channel UHF Remote

State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 Tx's can be learnt by one Rx (kit includes one Tx but more available separately). 4 indicator LED 's. Rx: PCB 77x85mm, 12Vdc/6mA (standby). Two *& Ten Channel versions also available.*
Kit Order Code: 3180KT - **£49.95**
Assembled Order Code: AS3180 - **£59.95**

Computer Temperature Data Logger

Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 45x45mm. Powered by PC. Includes one DS1820 sensor.
Kit Order Code: 3145KT - **£19.95**
Assembled Order Code: AS3145 - **£26.95**
Additional DS1820 Sensors - **£3.95 each**

Remote Control Via GSM Mobile Phone

Place next to a mobile phone (not included). Allows toggle or auto-timer control of 3A mains rated output relay from any location with GSM coverage.
Kit Order Code: MK160KT - **£13.95**

Most items are available in kit form (KT suffix) or pre-assembled and ready for use (AS prefix).

4-Ch DTMF Telephone Relay Switcher

Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 130 x 110 x 30mm. Power: 12Vdc.
Kit Order Code: 3140KT - **£74.95**
Assembled Order Code: AS3140 - **£89.95**

8-Ch Serial Port Isolated I/O Relay Module

Computer controlled 8 channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Includes plastic case 130x100x30mm. Power: 12Vdc/500mA.
Kit Order Code: 3108KT - **£64.95**
Assembled Order Code: AS3108 - **£79.95**

Infrared RC 12–Channel Relay Board

Control 12 onboard relays with included infrared remote control unit. Toggle or momentary. 15m+ range. 112 x 122mm. Supply: 12Vdc/0.5A
Kit Order Code: 3142KT - **£59.95**
Assembled Order Code: AS3142 - **£69.95**

Audio DTMF Decoder and Display

Detect DTMF tones from tape recorders, receivers, two-way radios, etc using the built-in mic *or* direct from the phone line. Characters are displayed on a 16 character display as they are received and up to 32 numbers can be displayed by scrolling the display. All data written to the LCD is also sent to a serial output for connection to a computer. Supply: 9-12V DC (Order Code PSU445). Main PCB: 55x95mm.
Kit Order Code: 3153KT - **£34.95**
Assembled Order Code: AS3153 - **£44.95**

Telephone Call Logger

Stores over 2,500 x 11 digit DTMF numbers with time and date. Records all buttons pressed during a call. No need for any connection to computer during operation but logged data can be downloaded into a PC via a serial port and saved to disk. Includes a plastic case 130x100x30mm. Supply: 9-12V DC (Order Code PSU445).
Kit Order Code: 3164KT - **£54.95**
Assembled Order Code: AS3164 - **£69.95**

EVERYDAY PRACTICAL ELECTRONICS

FEATURED KITS

Everyday Practical Electronics Magazine has been publishing a series of popular kits by the acclaimed Silicon Chip Magazine Australia. These projects are 'bullet proof' and already tested down under. All Jaycar kits are supplied with specified board components, quality fibreglass tinned PCBs and have clear English instructions. Watch this space for future featured kits.

August 2010

WATER TANK LEVEL METER KIT

KC-5460 £31.75 plus postage & packing

This PIC-based unit uses a pressure sensor to monitor water level and will display tank level via an RGB LED at the press of a button. The kit can be expanded to include and optional wireless remote display panel that can monitor up to ten separate tanks (KC-5461) or you can add a wireless remote controlled mains power switch (KC-5462) to control remote water pumps. Kit includes electronic components, case, screen printed PCB and pressure sensor.

Also available:
KC-5461 - Remote display kit £24.75
KC-5462 - UHF remote mains switch kit £29.00

Featured in EPE MAY 10

ULTRA-LOW DISTORTION 135WRMS AMPLIFIER MODULE

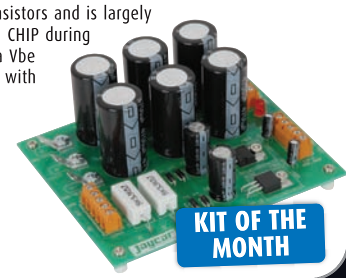
KC-5470 £27.75 plus postage & packing

This ultra low distortion amplifier module uses the new ThermalTrak power transistors and is largely based on the high-performance Class-A amplifier which was featured in SILICON CHIP during 2007. This improved circuit has no need for a quiescent current adjustment or a Vbe multiplier transistor and has an exceptionally low distortion figure. Kit supplied with PCB and all electronic components. Heat sink and power supply not included.

Output Power: 135WRMS into 8 ohms and 200WRMS into 4 ohms
Frequency Response at 1W: 4Hz to 50kHz
Harmonic Distortion: <0.008% from 20Hz to 20kHz

Also available:
Power Supply Kit for Ultra-LD Mk2 200W Amplifier (KC-5470) - KC-5471 £16.25

Featured in this issue of EPE



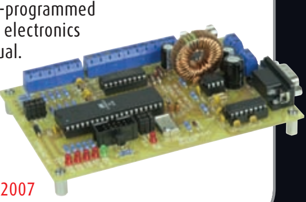
KIT OF THE MONTH

SMS CONTROLLER MODULE

KC-5400 £17.00 plus postage & packing

Control appliances or receive alert notification from anywhere. By sending plain text messages this kit will allow you to control up to eight devices. At the same time, it can also monitor four digital inputs. It works with old Nokia handsets such as the 5110, 6110, 3210, and 3310, which can be bought inexpensively. Kit supplied with PCB, pre-programmed microcontroller and all electronics components with manual. Requires a Nokia data cable which can be readily found in mobile phone accessory stores.

Featured in EPE March 2007



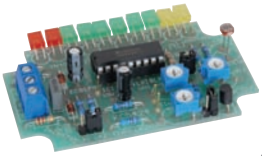
VOLTAGE MONITOR KIT

KC-5424 £6.75 plus postage & packing

This versatile kit will allow you to monitor the battery voltage, the airflow meter or oxygen sensor in your car. The kit features 10 LEDs that illuminate in response to the measured voltage, preset 9-16V, 0.-5V or 0-1V ranges, complete with a fast response time, high input impedance and auto dimming for night time driving. Kit includes PCB with overlay, LED bar graph and all electronic components.

- 12VDC
- Recommended box: UB5 use HB-6015 £0.83

Featured in EPE November 2007

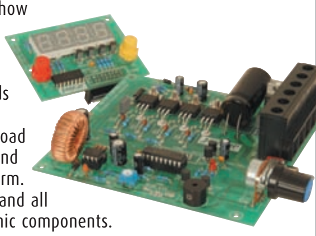


HIGH CURRENT MOTOR SPEED CONTROLLER KIT

KC-5465 £26.25 plus postage & packing

Controls a 12 or 24VDC motor at up to 40A continuous and features automatic soft-start, fast switch-off and a 4-digit display to show settings. Speed regulation is maintained even under heavy loads and the system includes an overload warning buzzer and a low battery alarm. Kit contains PCB and all specified electronic components.

Featured in EPE December 09/Janurary 10



PIC MICROCONTROLLER SERIAL PROGRAMMER KIT

KC-5467 £21.75 plus postage & packing

This very cost effective programmer kit can handle all the dsPIC30F family and almost all of the regular PICs available in a DIP package. It uses freely available software for PCs and is easy to build. Microchip offers free documentation and source code on their website so getting started should be a breeze. Supplied with screen printed PCB, 2 x 40 pin ZIF sockets and all specified components.

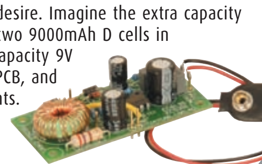
Featured in EPE May 2010

3V TO 9V DC TO DC CONVERTER KIT

KC-5391 £4.75 plus postage & packing

This great little converter allows you to use regular Ni-Cd or Ni-MH 1.2V cells, or Alkaline 1.5V cells for 9V applications. Using low cost, high capacity rechargeable cells, the kit will pay for itself in no-time! You can use any 1.2-1.5V cells you desire. Imagine the extra capacity you would have using two 9000mAh D cells in replacement of a low capacity 9V cell. Kit supplied with PCB, and all electronic components.

Featured in EPE June 2007

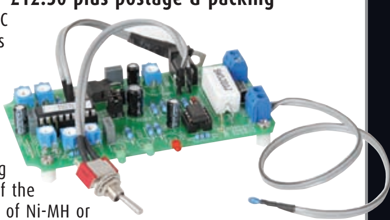


FAST NI-MH BATTERY CHARGER

KC-5453 £12.50 plus postage & packing

Ideal for RC enthusiasts who burn through a lot of batteries. Capable of handling up to 15 of the same type of Ni-MH or Ni-Cd cells. Build it to suit any size cells or cell capacity and set your own fast or trickle charge rate. It also has overcharge protection including temperature sensing. Kit includes solder mask & overlay PCB, programmed micro and all specified electronic components. Case, heatsink and battery holder not included.

Featured in EPE August 2009



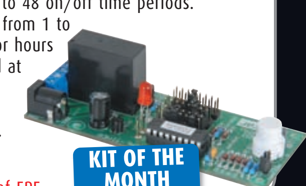
LOW COST PROGRAMMABLE INTERVAL TIMER

KC-5464 £10.25 plus postage & packing

Here's a new and completely updated version of the very popular low cost 12VDC electronic timer. It is link programmed for either a single ON, or continuous ON/OFF cycling for up to 48 on/off time periods. Selectable periods are from 1 to 80 seconds, minutes, or hours and it can be restarted at any time. Kit includes PCB and all specified electronic components.

- PCB: 102 x 42mm

Featured in this issue of EPE



KIT OF THE MONTH

THE FLEXITIMER KIT

KA-1732 £6.00 plus postage & packing

This kit uses a handful of components to accurately time intervals from a few seconds to a whole day. It can switch a number of different output devices and can be powered by a battery or mains plugpack.

- Kit includes PCB and all components
- Requires 12 - 15 VDC power

Featured in EPE May/June 2008

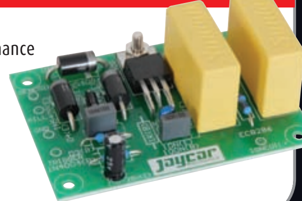
CDI IGNITION MODULE REPLACEMENT KIT

KC-5466 £6.50 plus postage & packing

Many modern motor bikes use a Capacitor Discharge Ignition (CDI) to improve performance and enhance reliability. However, if the CDI ignition module fails, a replacement can be very expensive. This kit will replace many failed factory units and is suitable for engines that provide a positive capacitor voltage and have a separate trigger coil. Supplied with solder masked PCB and overlay, case and components. Some mounting hardware required.

- PCB: 45 x 64mm

Featured in EPE July 2010



Jaycar Electronics

Freecall order: 0800 032 7241

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- 4012B £0.16
- 4013B £0.24
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- 4017B £0.26
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- 4029B £0.38
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- 4040B £0.24
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- 4042B £0.19
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- 4046B £0.42
- 4047B £0.25
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- 4049B £0.29
- 4049UB £0.17
- 4050B £0.20
- 4051B £0.23
- 4052B £0.32
- 4053B £0.20
- 4054B £0.56
- 4055B £0.34
- 4060B £0.17
- 4063B £0.41
- 4066B £0.22
- 4068B £0.19
- 4069UB £0.18
- 4070B £0.15
- 4071B £0.20
- 4072B £0.25
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- 4075B £0.17
- 4076B £0.30
- 4075B £0.15
- 4077B £0.28
- 4078B £0.30
- 4081B £0.13
- 4082B £0.21
- 4085B £0.28
- 4086B £0.33
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- 4094B £0.29
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- 4099B £0.35
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- 4508B £1.40
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- 4512B £0.27
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- 4520B £0.34
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- 4527B £0.40
- 4529B £0.44
- 4532B £0.24
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- 4541B £0.33
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- 74HC11 £0.21
- 74HC14 £0.18
- 74HC20 £0.28
- 74HC27 £0.16
- 74HC30 £0.22
- 74HC32 £0.14
- 74HC42 £0.36
- 74HC73 £0.40
- 74HC74 £0.15
- 74HC75 £0.31
- 74HC85 £0.23
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- 74HC126 £0.46
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- 74HC133 £0.34
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- 74HC139 £0.31
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- 74HC158 £0.23
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- 74HC162 £0.45
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- 74HC164 £0.20
- 74HC165 £0.26
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- 74HC174 £0.27
- 74HC175 £0.35
- 74HC193 £0.39
- 74HC195 £0.32
- 74HC240 £0.32
- 74HC241 £0.37
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- 74HC245 £0.34
- 74HC251 £0.30
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- 74HC257 £0.25
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- 74HC273 £0.32
- 74HC299 £0.61
- 74HC365 £0.28
- 74HC367 £0.38
- 74HC368 £0.29
- 74HC373 £0.35
- 74HC374 £0.34
- 74HC390 £0.37
- 74HC393 £0.36
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- 74HC595 £0.27
- 74HC597 £0.22
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- 74HC4017 £0.24
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- 74HC4040 £0.29
- 74HC4049 £0.31
- 74HC4051 £0.50
- 74HC4052 £0.34
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- 74HC4060 £0.23
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- 74LS03 £0.21
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- 74LS05 £0.14
- 74LS08 £0.19
- 74LS09 £0.15
- 74LS10 £0.27
- 74LS11 £0.17
- 74LS12 £0.25
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- 74LS20 £0.27
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- 74LS32 £0.23
- 74LS37 £0.31
- 74LS38 £0.18
- 74LS40 £0.14
- 74LS51 £0.24
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- 74LS85 £0.48
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- 74LS93 £0.44
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- 74LS109 £0.21
- 74LS112 £0.24
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- 74LS114 £0.36
- 74LS122 £0.31
- 74LS123 £0.31
- 74LS126 £0.25
- 74LS132 £0.47
- 74LS133 £0.36
- 74LS136 £0.23
- 74LS138 £0.33
- 74LS145 £0.56
- 74LS148 £0.64
- 74LS151 £0.29
- 74LS156 £0.36
- 74LS157 £0.22
- 74LS158 £0.21
- 74LS160 £0.48
- 74LS161 £0.32
- 74LS162 £0.44
- 74LS163 £0.32
- 74LS164 £0.43
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- 74LS240 £0.32
- 74LS241 £0.32
- 74LS243 £0.30
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- 74LS245 £0.45
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- 78S15 £0.32
- 7905 £0.23
- 7912 £0.24
- 7915 £0.22
- 7924 £0.38
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- 6A10 £0.35
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- 1.5A 1kV £0.18
- 2A 100V £0.34
- 2A 200V £0.34
- 2A 400V £0.35
- 2A 800V £0.36
- 2A 1000V £0.45
- 3A 200V £0.34
- 3A 400V £0.40
- 3A 600V £0.33
- 3A 1000V £0.33
- 4A 100V £0.78
- 4A 200V £0.80
- 4A 400V £0.86
- 4A 600V £0.90
- 6A 100V £0.49
- 6A 200V £0.64
- 6A 400V £0.53
- 6A 600V £0.67
- 6A 800V £0.37
- 8A 100V £0.98
- 8A 200V £1.00
- 8A 400V £1.20
- 8A 600V £1.33
- 8A 1000V £1.05
- 25A 100V £1.47
- 25A 200V £1.54
- 25A 400V £1.98
- 25A 600V £1.82
- 35A 100V £1.57
- 35A 200V £1.80
- 35A 600V £1.90
- 35A 1000V £2.32

Potty about Pots!
We now carry in stock a wide range of positive position pots.
With either with a centre click or 41 click positions. Log, Lin, Single or Dual gang.

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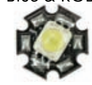

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Reading on the go...

You don't have to be an Apple obsessive to know that the big news in the world of consumer electronics last month was the release (outside the US) of the iPad. This is the latest gizmo for reading books, browsing the internet, sending emails and a whole host of other functions based on free and paid-for 'apps' (application programs). Apps range from the mundane and useful to the silly and occasionally weird – there is even a fantastically pointless app for simulating a stapler – as well as others that are not really appropriate for discussion in EPE!

The iPad joins other devices, such as Amazon's Kindle, in offering a new way to access and read books, newspapers and yes, you guessed it, magazines like EPE. How successful these will be remains to be seen, but I am pleased to note that both support the PDF format, which is how online subscribers receive their copies of EPE. A nice feature of the iPad is that in the next iteration of the device's operating system you will be able to highlight text and add your own notes and bookmarks to PDFs, including presumably, PDFs of articles and projects from EPE. It is little 'value-added' features like this that will help to make the online version of books and magazines just as flexible and useful as the printed ones.

We are following the progress of these devices and file formats with interest, and would be interested in hearing the opinions of readers and subscribers as to how successfully they can access and read EPE using different kinds of handheld readers.

From the 'paperless office', first touted in the 1980s, to the contemporary e-publication revolution, the predictions of paper's demise have been widespread, and in most cases simply wrong. We expect to support both formats for the foreseeable future – both media have their advantages and disadvantages, and we are pleased to be able to give you a choice.

Matt

Editor: MATT PULZER
Consulting Editor: DAVID BARRINGTON
Subscriptions: MARILYN GOLDBERG
General Manager: FAY KEARN
Editorial/Admin: (01202) 873872
Advertising and Business Manager: STEWART KEARN (01202) 873872
On-line Editor: ALAN WINSTANLEY
EPE Online (Internet version) Editors: CLIVE (Max) MAXFIELD and ALVIN BROWN
Publisher: MIKE KENWARD

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Email: techdept@epemag.wimborne.co.uk
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PROJECTS AND CIRCUITS

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.
A number of projects and circuits published in *EPE* employ voltages that can be lethal. You should not build, test, modify or renovate any item of mains-powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers.
We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

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We advise readers that certain items of radio transmitting and telephone equipment which may be advertised in our pages cannot be legally used in the UK. Readers should check the law before buying any transmitting or telephone equipment, as a fine, confiscation of equipment and/or imprisonment can result from illegal use or ownership. The laws vary from country to country; readers should check local laws.

NEWS

A roundup of the latest Everyday News from the world of electronics

Analogue radio – the great switch off **By Barry Fox**

The UK now has something vaguely resembling a timetable for analogue radio switch off.

The Digital Economy Act says it can happen, and government 'explantory notes', coupled with last year's *Digital Britain Report*, suggest that if there is 50% digital listening by 2013, analogue stations will switch off in 2015.

No official body – not even Digital Radio UK, the body in charge of digital radio switchover – has explained the situation clearly. To fill the information vacuum, British manufacturer Pure recently produced trade and consumer booklets, which try to 'dispel radio switchover myths'.

Pure's marketing director, Colin Crawford, objects to emphasis on the 2015 date, calling it a 'distraction', because 'what matters is that switchover is going to happen'.

'When people buy radios they expect them to still be working in ten or twenty years,' he says. 'What really matters is that when someone goes into a dealer this weekend, the sales staff have to tell them that if it's analogue only it is going to stop working in a few years.'

There are at least 200 million radios in UK homes. 'But many of those 200 million are not in use,' argues Crawford. 'At most there are 50 million to replace'.

In the USA, analogue TV was switched off overnight and viewers were given a coupon for a free digital converter. Giving away 200 million radio coupons is out of the question.

'But one per household might work' says Crawford. 'And in France, they passed a law a year ago which says any new radio sold after September 2012 must support digital reception, and any new car sold after September 2013 too'.

This parallels French laws passed that made SCART sockets compulsory on TVs.

In-car listening is a major obstacle to analogue switch off. Although the BBC has been broadcasting DAB since 1995, cars and vans are still being sold without a DAB option and without an aerial that will allow a dashboard DAB radio retrofit. Even if the UK weren't too small a market to influence world motor design, it takes the motor trade around five years to change production.

There are currently around 33 million vehicles driving around without DAB, and because many people like to keep their cars for a while, there will still be around 20 million no-DAB vehicles by 2015.

Around 20% of radio listening is in-car, and much of that is prime time, so worth more in advertising.

In-car traffic data relies on FM – from the Classic FM Traffic Message Channel – not DAB.

Switchover has another obstacle – the promise of DAB+ compression coding, which is two or three times more efficient than regular DAB. Older DAB radios cannot receive DAB+, and although new radios sold on the Continent have DAB+, in the UK the feature is usually not activated in order to avoid the US 98 cent royalty fee.

So, realistically, DAB+ can only be used in the UK for additional services, not migration of existing stations.

Exciting new projects from Jaycar Electronics

May 2010 saw the release of four new kits from Jaycar Electronics.

The 'Solar Powered Shed Alarm' kit (KC-5494 £8.75) is designed to help keep your valuable tools and equipment safe and secure in your shed. This solar-powered alarm is not just for sheds, but any location where you want to keep undesirables out, but don't have access to mains power – a boat on a mooring, for example. It has three inputs, so you can add extra sensors as required, plus all the normal entry/exit delays etc. It is short form kit only – add your own solar panel, SLA battery, sensors and siren.

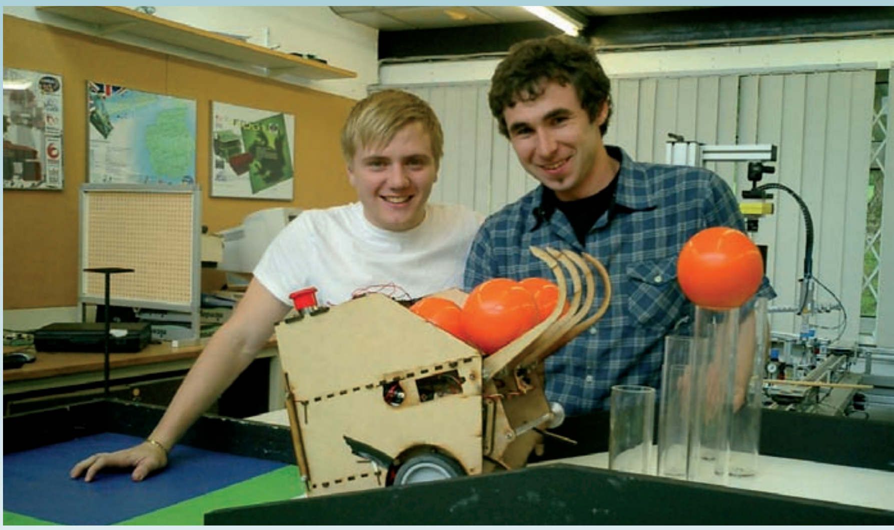
Next, is the 'Low Capacitance Adaptor for DMM' kit (KC-5493 £10.25). Many modern multimeters come with capacitance ranges, but they're no good for very small values. This kit is a nifty little adaptor that allows a standard digital multimeter to measure very low values of capacitance, from less than one picofarad to over 10nF. It will allow you to measure tiny capacitors or stray capacitances in switches, connectors and wiring. The kit is complete with PCB, components and case. All you'll need is a 9V battery and just about any modern DMM.

The 'High Performance 12V Stereo Amplifier' kit (KC-5495 £13.25) is an ideal project for anyone wanting a compact stereo amp that can be run from a 12V DC source. It can be used for busking or any application where 12V power is available. No mains voltages means it's safe as a school project or as a beginner's first amp project. The performance is excellent, with 20W RMS per channel at 14.4V into 4Ω and THD of less than 0.03%.

Last, but not least, the 'SD/MMC Card Webserver In a Box' kit (KC-5489 £26.25) allows you to host your own website on a common SD/MMC card in a compact 'Web server In a Box' (WIB). It connects to the Internet via a modem/router and features inbuilt HTTP server, FTP server, SMTP email client, dynamic DNS client, RS232 serial port, along with four digital outputs and four analogue inputs. The kit requires an SD memory card, some SMD soldering and a 6V to 9V DC power adaptor. The kit includes PCB, case and electronic components.

Further information: **www.jaycar.com.au**.

Middlesex Uni teams in 2010 Eurobot finals



Three teams of Middlesex University students represented the UK at the *2010 Eurobot World* finals, held in Switzerland at the end of May.

Eurobot is an international amateur robotics contest open to teams of two people under the age of 30. Three Middlesex student teams were selected from the UK finals, where they triumphed over five other teams, beating entrants from other UK universities and a team from a commercial company. The Middlesex teams then went forward to the Eurobot Finals, competing with entrants from over 25 European and other countries for the chance to win the Eurobot Trophy.

Middlesex University offers product design and robotics courses at undergraduate and postgraduate levels. Courses have a particular focus on designing small-scale remote-controlled robots known as 'autonomous vehicles'. Earlier this year, a Middlesex team also achieved world-wide recognition when they exhibited the 'Heineken Bot', a robot which can be programmed to move along a specified path and serve glasses of beer, at London's *Kinetica Art Fair*.

In the UK finals, held in April, the Eurobot teams faced the 'Feed the world' challenge, which involved designing an autonomous robot, which was then programmed to move along a track collecting coloured balls, which represented different fruits. Each 'fruit' had a different points value – the teams with the highest number of points were the winners of the competition.

All three teams proceeded to the Eurobot Finals later in May, where they played the 'Feed the world' challenge against ten times as many teams.

Dr Stephen Prior, principal lecturer in product design and engineering at Middlesex University, said: 'The greatest test for participants is to make a reliable machine that works every time and the competition results show the hard work which all the teams put into their designs has really paid off.'

Middlesex students have also competed in the MoD Grand Challenge 2008, building robotic systems designed to detect threats to soldiers in areas of urban conflict. They have also participated in TV series such as *Robot Wars* and *The Gadget Show*.

The Eurobot World Finals took place in Rapperswil-Jona, Switzerland, on 26-30 May, where the top placed Middlesex team came a commendable sixth out of 46 teams.

HP and Bletchley Park to collaborate on digitising site's World War II archives

Hewlett Packard has announced that it will be collaborating with Bletchley Park, the site of the United Kingdom's main counter-intelligence decryption activities during World War II, to digitise the Park's vast archive of historical documents and make this accessible to the public in digital format.

HP will be working with the Bletchley Park Trust, which runs Bletchley Park's National Codes Centre and its museum and educational facilities, to donate and deploy document management and scanning technologies to help commit over 1,000,000 of the site's historic documents to digital format. The documents include communication transcripts, communiqués, memoranda, photographs and other material tracing and referencing some of the most significant events of the Second World War.

Digitising the archive will help preserve its records and give members of the general public – including users outside the United Kingdom – their first ever chance to easily search stories and material on historical events documented in the archive, as well as transform the research process for academics and educators.

The high-level intelligence produced by under-cover mathematicians and military operatives at Bletchley Park during the War – codenamed *Ultra* – provided crucial assistance to the Allied war effort and is credited with having determined many of the key outcomes of the conflict. This includes activities that decrypted many of Germany's military communications generated by the Enigma (thought to be unbreakable) and Lorenz machines, and which informed critical Allied counter-espionage strategies and activities designed to counter the German war effort. Their success reduced the length of the war by an estimated two years, saving many lives.

PScope app for iPhone/iPad

An avid PicoScope user has created a new app for use with a scope. 'PScope' is a remote controller and viewer for any scope from Pico Technology's PicoScope 2000 Series on the iPhone and iPad. This is the first app for use with an oscilloscope that has been accepted into the Apple Appstore.

The app supports two oscilloscope channels with the full range of voltage ranges and timebases; three triggering modes with variable pre-trigger, trigger level and edge selection and AC/DC coupling on both channels. Planned features include AWG control.

The app costs £2.99 and can be downloaded from the app store; simply search for PScope. You can preview the app on YouTube at: **http://tinyurl.com/32cvabv**

Contralube 770 – available in Maplin shops

Contralube is a product for use with multi-pin connectors, spade, bullet and any other type of push-fit electromechanical contact area. It tackles the problem of vibration corrosion, oxidation, intermittent circuitry faults/gremlin problems, water penetration and general weatherproofing issues.

Initially it was only available through a small number of retailers, but Maplin purchasing staff have now decided to make Contralube 770 available to purchase in selected Maplin retail shops. The full list is available at: **www.contralube.com.**

Flowcode V4 for ARM

Matrix Multimedia has announced it expects Flowcode V4 for ARM to be released by the end of June. This will be the last microcontroller to be released in the version 4 series.

Work has already begun on Flowcode for dsPIC/PIC24, and Matrix will issue further news of both this and preliminary work on Flowcode 5 in the coming months. All suggestions for future features and improvements are welcome – **www.matrixmultimedia.com**.

Back up, and back up again!

CDs used for backing up data can forget all too quickly, the French National Centre for Scientific Research has found out after testing the longevity of the portable media.

'We were surprised to see that the lifetime of discs, some of which were designed to last for centuries, actually rarely lasted longer than five to 10 years,' said physicist Franck Laloe. 'In the most severe cases, which were happily quite rare, the data on some discs lasted just one year,' he said.

The researchers' conclusion is simple: 'You must have your information in two places at least – on a hard disc, and on another hard disc or on a recordable DVD or CD.'

How to make your own PCBs

By TONY THOMPSON BSc., Cert. Ed.

Using the Seno etch-in-a-bag kit, Tony outlines his preferred approach to producing printed circuit boards

UNTIL relatively recently the making of good quality 'custom' PCBs (printed circuit boards) at home was a tricky business. It was impossible to replicate the industry process where the artwork for commercially made boards was created by skilled draftsmen working to a large scale, followed by photographic reduction of the artwork to final board size.

The equipment to do this and to create the silk-screen patterns for etch-resist printing was specialised, bulky and costly, and required a degree of specialised skill.

Limitations

During the latter part of the 20^{th} century, advances in computing power greatly improved drafting methods and also opened the way for the commercial use of CNC machinery for computer-controlled milling, especially for prototypes and short runs. Even so, for a long time board design on home computers was limited in scope – think of Pineapple PCB on the old BBC computers, if you are old enough to remember them.

All but the most basic of programs were expensive and processing continued to need equipment that was hardly an economical proposition. The majority of home constructors created their boards with hand-drawn tracks using an etch-resist pen directly onto the copper laminate, or press-down etch-resistant transfer shapes for pads and tracks.

These methods are time-tested, straightforward and reliable and still have their uses, especially for simple prototyping – but they suffer from the limitations imposed by 1:1 working. It is very difficult to pen-draw a complex PCB pattern, and the track patterns of boards created in this way tend, even at best, to look crude and amateurish – although how much importance the constructor assigns to this aspect is very much a personal choice.

In fairness, transfer shapes do enable the accurate placing of pads for multi-pin components such as DIL chips, but they require dexterity in use and there remains a limit to the track and component density that can be achieved. It is self-evident that the more complex the design, the greater the possibility of error. Hand-drawn or self-adhesive, both require the use of 'conventional' acid etching, with its attendant problems.

Times have changed

The home computer of today can provide the enthusiast with access to remarkably comprehensive computer-aided design facilities of a quality and range that would only have been dreamed of in previous years. It is this, plus the safety and simplicity in use of the Seno range of applicators and chemicals that can truly be said to have revolutionised home production.

Some of the Seno applicator range

Tips for successful computer PCB design

Consider netlisting

In the example board shown, *Express SCH and *Express PCB free-download software (see end of article 'Notice Board') was used to create a single-sided board for simplicity of demonstration. With such a basic board design it was unnecessary to link the schematic diagram to the PCB design via a netlist; but netlisting is well worth considering when creating more complex or multi-layered boards as it highlights layout errors.

Corner guides help location

During the process of designing a board, the addition of cross-wire corner guides can be of help in the subsequent location of the laminate and are useful for the same purpose when etching double-sided boards. The same cross-wires may also be the location of the board's mounting holes – see photographs.

I feel it is preferable to obtain all components before the board design begins, as the positions, pad locations and physical size of components can be measured directly on intermediate paper printouts, greatly reducing positioning errors.

Identify and date your boards

Working on the upper component side of a single-sided board – the silkscreen side – you should number or otherwise identify components and external connection points, or risk finding that what makes perfect sense to you one day seems like a meaningless jumble the next. Or perhaps that's just me!

Note that any identifying lettering or numbering you apply to the underside copper of the board may be reproduced in mirror image when etched, though most PCB design programs automatically reverse the lettering so that it will be etched to read correctly. But in any case, don't overload your copper layer with numbering and wording, other than to identify and date your board designs for future reference. This can be done both on copper and silkscreen layers, the latter also being used for component numbering and positioning.

In case you are wondering, silk screen printing refers to the commercial practice of overprinting the plain top board surfaces with component shapes and identifications. Silk screening is not necessary for home PCBs, nor is it economic to achieve, but a passable printed paper version of the silkscreen layer can be glued to the top of single-sided boards – to aid construction.

Danger of undercutting

Narrow tracks and tiny pads may look good, but it is best to avoid over-thinning them or undercutting by the acid could create a hard to locate break. The central hole diameter for pads can, with some advantage, be selected for a smaller size — I find the 'default' sizes are sometimes too large for the copper pad, leaving only a very thin ring of copper remaining, which hinders soldering.

It is good practice to keep tracks broad and pads large as far as practicable, consistent with appearance. After all, your board should look good, shouldn't it.

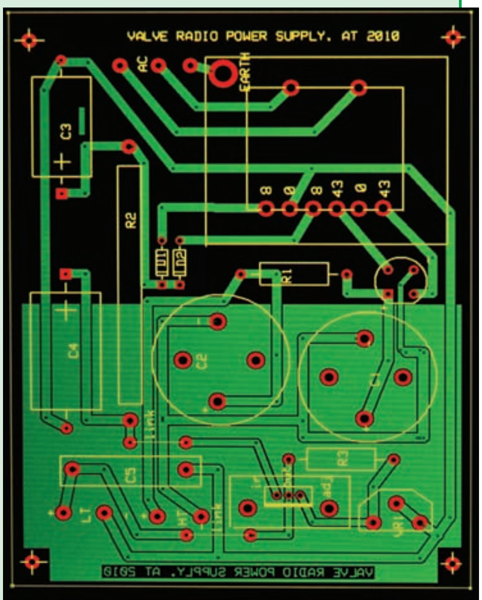
Print a large scale checking version

It is important to print (1:1) the PCB track pattern on paper and manually check for errors before you commit to a transparency, and certainly before you actually etch a board. Also, 1:1 print allows you to try components for accuracy of pad locations.

Where size allows, it is also helpful to print an enlarged copy on paper of the completed design. This makes close and careful examination easier when checking for any problems. The great beauty of computer-aid design is the endless ability to make adjustments, something that is much more time-consuming with pen-drawn or adhesive work.

Add land area, save etchant

If you intend to etch several boards, consider designing your patterns for maximum 'land area', ie areas of non-etched copper. There is a definite correlation between the amount of copper dissolved and the useful etchant life, because etchant becomes exhausted when the levels of dissolved copper reaches saturation. These 'lands' do not have to be connected with tracks, and can be there simply to save the etchant and speed up the etching process.



Screen shot of PCB, one half with a filled plane, the other clear. The amount of etching required is considerably less when planes can be used.

Depending upon the type of circuit and also the facilities offered by the program you use, you may be able to employ a 'ground plane', 'power plane' or 'filled plane' — all differing names for much the same thing, an area of solid copper surrounding the pads and tracks, generally used to provide a ground or earth return.

Most programs allow the easy generation of these planes. Apart from the technical advantages they offer (including screening when used with double-sided board) they add to the professional appearance of finished boards. The example shown has been rather overdone but it does demonstrate the principle. Note how the plane automatically spaces itself from pads and tracks.

Gloves on

It is best to protect your hands with latex or similar disposable gloves. This applies regardless of the chemicals used – even though the Seno range of applicators are clean-working. Gloves also prevent finger-contamination of the bare copper surface. You must also wear goggles to protect your eyes.

The innovative Seno product range (used in this article) allows minimal physical contact with the work and virtually eliminates the likelihood of chemical contamination. In fact, when used with reasonable care, spillage from the applicators is negligible. In the author's opinion, there is little on the market to compete with them in terms of practicality and clean working for home PCB manufacture.

Before venturing further, it is perhaps worth pointing out that despite the superiority of CAD programs for the more complex track patterns, it is still possible to use self-adhesive pads and tracks for relatively simple boards and process them safely with the Seno chemicals.

Computer-aided design

Computer-aided PCB design software (such as the excellent packages offered by Labcenter Electronics, **www.labcenter.com**) really comes in to its own if your needs dictate a compact board or one with a high component count, based upon either a schematic of your own devising or one you cannot obtain a track layout for. There are numerous programs devoted to the production of PCB track patterns, some of which are free for download.

These enable good quality layouts to be produced, and though there are variations from program to program, basic features are common to most, such as the ability to create multiple layer boards, automatic 'ground' or 'power plane' facilities and netlisting to check track patterns against schematic diagrams generated by the same or a sister program. All offer a library of component types, sizes and pads to make the layout of boards a straightforward procedure. You can also create your own customised shapes for occasions when nothing 'off the peg' will fit.

Such free programs are intentionally designed to persuade you to opt for their allied PCB production facilities by the use of output formats that may be emailed directly to them. Despite this, home production of printed track pattern transparencies is normally entirely practical. If you do not wish to be encumbered, even if marginally, by the limitations imposed by free programming, there are numerous PCB design programs to purchase.

Step-by-step to success

Both the pen and the self-adhesive track-and-pad methods can, as already pointed out, be used with Seno products, or with other available chemicals; but for really professional-looking results, use your computer with a suitable dedicated PCB graphics package or download or photocopy your track pattern as described in the following guide.

1. Using existing track and pad patterns

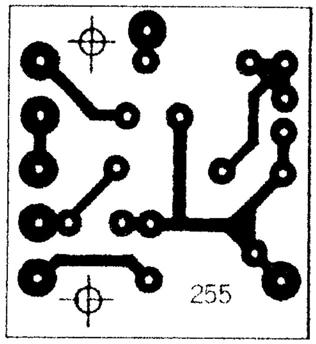
Where PCB track patterns are printed 1:1 scale in magazines they can be copied by photocopier or scanner. With the former you have to accept that any slight raggedness or blemish will be repeated on the copy. Photocopier printouts can be on clear film. It can be difficult to obtain adequate density. In such cases it may be better to print on plain paper (see later).

Scans can be improved on the computer to minimise reproduction losses due to the printing process and the paper used: imperfections like ragged edges, areas of lower density and drop-outs of the black print can be corrected by the use of general graphic enhancement programs, such as Paint Shop Pro or Photoshop. The example layouts showing 'before and after' were taken from the pages of *EPE*.

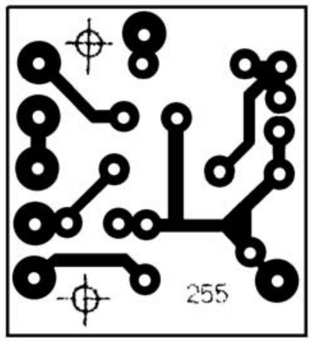
When using a scanner to copy work to the computer, select greyscale setting at a high resolution, say 400 dpi. This becomes more important with very small area PCBs. Resolution can always be reduced to a more manageable size after scanning. Do not scan in black/white; greyscale allows greater flexibility of manipulation of the graphics and slight changes of either brightness or contrast can provide much-needed clarity.

Save your work in any convenient form: GIF or BMP work well. With JPGs, play safe and minimise any possibility of fuzziness or compression artifacting by saving in the highest quality.

Don't forget that *EPE* have downloadable material, including PCB layouts to suit many of their back-catalogue projects in the convenient .pdf form, only requiring the use of Adobe Acrobat or the free-for-download Acrobat Reader in order to produce quality artwork.



Scanning PCB patterns from magazines may produce ragged edges



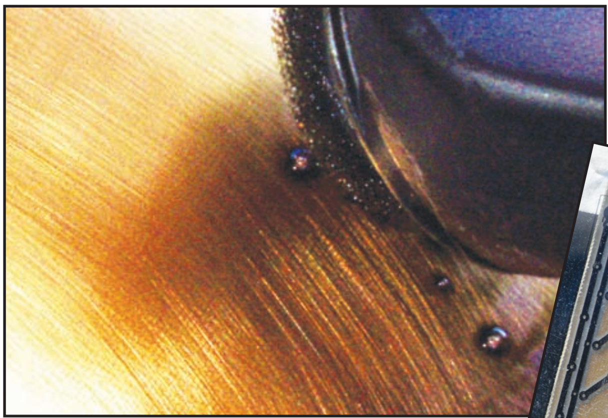
The same pattern improved using a PC paint program

2. Printing your design

After designing or obtaining your layout, the next step is to print, either on clear film or paper. I use an inkjet printer for this purpose, and sometimes in the past, when using transparencies, I've found it useful to pass the printed film back through the printer to deposit a second layer of ink to ensure density of the black pattern, something essential to the success of home-produced boards.

However, with some printers, slight shifts in the film take-up may risk a double pass causing blurring of the design, but if your PCB designer won't allow you to set your printer to high quality – and some will not, at least in a direct manner – you can try this, but don't forget that printer settings can also be accessed via the 'printers and faxes' tab on the PC's start menu, allowing you to set your printer to work with clear film at high quality.

Not all inkjet printers run happily with film. For example, I have an Epson SX400, which has a habit of chewing up acetate film stock, yet my other inkjet printer, a Canon 1P5200, takes the film as well as it takes normal paper and produces excellent prints. It pays to experiment.



Above: Applying photoresist using the Seno applicator. It dries quickly and the board must be immediately rocked to prevent the build-up of thickened ridges.

Right: The window doesn't have to be clean! UV light penetrates. A south-facing window is best for reliable UV exposure.

Remember to print on the textured side of inkjet film, not the clear. If you have access to a laser printer you might want to try clear laser film. Do ***not*** attempt to pass inkjet film through a laser printer.

An alternative to clear film

One last, but important point: though seemingly desirable, clear film prints are definitely not essential. It is possible to make a paper-based photocopy or laser print translucent to UV light by spraying the back of the print with WD40 or a similar product.

This will tend to slow down the exposure process due to the lessening of light transmission through the paper fibres, but it will give good results, sometimes superior to transparent cells. It must be a laser print, however. Don't try using WD40 on an inkjet print or you risk the ink running due to WD40's solvent action.

3. Board preparation

When working with plain laminate, the copper layer must first be cleaned, and for this you could use fine wire wool, but a better method is to use the Seno SN130 deoxidiser, which will degrease and clean the copper laminate, ready for the application of Seno SN100 photo-resist or your choice of photo-sensitive spray. Boards are normally coated with a positive photo-resist, ie the parts subsequently exposed to ultra-violet light will be the ones stripped away.

If you choose to spray, this should be applied with the copper side up and the board kept flat and level to prevent pooling or 'curtaining' of the spray. Hold the spray can about 150mm to 200mm (or as recommended on the can) from the surface and use smooth, steady strokes from end to end of the longest axis of the board, starting and finishing off the board. As far as possible, aim for an even coating.

My experiences with some brands of aerosol photo-resist have been mixed, to say the least. Personally, I prefer the reliable Seno applicator method; but even with this, it's not easy to obtain an even coating, though it is simpler and cleaner in use.

Working in semi-darkness, charge the applicator by pressing the pad gently onto the board and then quickly wipe it across the copper surface, no time to waste. DO NOT OVERLOAD; a thin film is all that is needed.

Pick the board up and gently tilt it first one way then another, watching as the liquid pools more evenly across the surface. It will 'set' rapidly and unless you wear those latex gloves you will stain your fingertips. That's about it. Results are rather variable and it must be stressed that a coating free from thickened ridges is essential for a successful outcome.

Allow sprayed or Seno-coated boards to dry well away from direct light sources, ideally in complete darkness. Overnight is, therefore, a good period for this and should ensure a firm, hard-dry surface for the next process.

As an alternative to coating your own boards, you can choose a pre-sensitised board, which has the photo-sensitive coating already in place. You simply peel back the protective film – but only when you are ready to make the exposure. More expensive than the DIY option, but also more reliable.

4. Exposure of the photosensitised layer

The clear film or WD-40 translucent paper track pattern print is taped in place on the board, ready for UV exposure. Be sure to put it the right way around, ie when the pattern has been created for conventional top-surface component mounting with the tracks and pads on the underside, place the printed side, not the clear side, in contact with the coating.

With double-sided boards, only the bottom pattern should be placed in this manner – the top one should probably have its printed surface uppermost (but check this with the program you are using).

Chemical changes occur in the sensitive emulsion on the board when it is exposed to UV light passing through the film, causing it to dissolve in the developer used to strip the exposed area away. The unexposed areas – the tracks and pads on the film – remain fixed because the densely printed pattern prevents UV light transmission from reaching them.

Let there be light

Unfortunately, dedicated UV light boxes are expensive and when producing only a few boards each year, the cost is a major drawback. For those not wishing to build the excellent light box described in this issue, there is a source of UV light and best of all, it's free – sunlight.

On average, just two per cent of UV light from the sun reaches ground level, the rest is absorbed by the atmosphere. Two per cent is, as it

happens, quite adequate for our purpose. Just tape your film/board assembly firmly against a clean south-facing window to expose it. I use one of my workshop windows and fix it in place with masking tape.

Note that very bright sunlight is ideal, but not essential because UV light penetrates cloud layers. It just takes longer to produce the desired effect.

Make a test strip

The trick is to know how long to expose the board for, and for that purpose it is sensible to use a test strip of sensitised board (a thin off-cut will do, provided there's enough area to show a track pattern for the test). In use, I have found exposure times as short as four minutes and as long as 15 minutes, due to the wide variations both in coating sensitivity and intensity of sunlight.

So, a test should be made on a suitable day using a spare strip of board prior to full board exposure. To minimise any error, this is best done in settled sunny conditions immediately before exposing the full board.

Tape a film with any kind of track pattern to the strip and use a piece of card as a sliding blind to step-expose in four or more increments of two minutes. The strip must be from exactly the same source as the final board or its validity will be in doubt.

Choose your day

The test pattern must then be developed (see below) and will provide a useful way to determine the optimum period of exposure. You may well find there is considerable latitude across the timing range, with good exposure often being obtained within four to eight minutes on a bright sunny day.

Shorter than four minutes may result in under exposure, which when developed will leave unwanted coating on the board. Beyond the eight minute period, there is the danger of over-exposure due to leakage of light through the black print areas. This will weaken the coating, with the result of loss of the essential track protection when developed.

The importance of a densely printed pattern cannot be over-emphasised. Once you have arrived at a suitable exposure period – whether you have the use of a light box or have used the sunlight method – the full board can safely be exposed.

Using a developer applicator. All the Seno applicators work in a similar manner

It is important to ensure that the pattern is in close contact with the board. In a light box, this is automatic, usually by a pressure pad in the lid.

With the sunlight method, you may need to resort to pressing your hand (or lean a length of timber) against the back of the board for the period of exposure. Failure of this part of the process will show itself by undercut or fuzzy tracks and pads.

5. Developing

The board now requires the exposed areas of photo-resist to be removed in order that the etching acid can come into contact with bare copper. Developer can be purchased in liquid or powder form, the latter being the best for shelf life. Again, wear protective gloves and goggles. Work steadily and carefully to avoid spillage or splashes.

Powder developer must be mixed with water. Pour it into a shallow tray and immerse the board face-up. You will see the process working as the developer removes the unexposed light-sensitive coating, revealing the fixed pattern of the tracks. When completed, remove and wash thoroughly to eliminate any trace of the developer before etching.

However, developing is easier using the Seno SN110 or SN111 developer applicator. SN110 is a standard universal developer and SN111 is gentler in action, designed for use with freshly applied or sprayed-on resists.

Lay the board, copper side uppermost, on a pad of old newspaper. Dapple the exposed sensitive coating then wait for a few seconds. You should see the track pattern emerge more prominently at this point. Gently stroke the pad over the board and watch the pattern strengthen as the copper is exposed.

Your development is complete once all traces of excess coating have been removed, leaving intact only the coating replicating the copper track pattern. The board can now be washed to remove all traces of the developer.

6. Etching

The developed board should now have all the exposed sensitised waste cleared, with only the track pattern remaining. It is now ready for etching, which can conventionally be by immersion in FeCl (ferric Chloride) solution, in a shallow tray – the ones that were sold for photographic development are ideal and so, with the proviso that your board will fit, are the clear plastic trays provided by your local Indian or Chinese take-away, only eat the food first. Alternatively, you can use the Seno system, described below.

With the open-tray method, you must obtain FeCl pellets (see also below under 'the trouble with acid'). When etching, the solution can be warmed to speed the process and the easiest way to do this is to stand the tray in a similar but larger tray with quite warm water as the heating medium. There may be some fumes when acid is heated.

If the etching is too fierce in action, or the tracks become excessively undercut, the solution can be further diluted down to about 2:1 to soften the action.

Protect yourself

Apologies for any repetition, but eye protection and latex or similar disposable gloves are important safety measures, and the wearing of old or protective clothing is also very strongly recommended for both developing and etching, but especially the latter process.

If it is your misfortune to swallow any quantity of the chemicals, (the acid tastes vile..) wash out mouth and nose and get down to your nearest hospital casualty department to explain what has happened. Injury to eyes is the biggest risk, so if you splash any in your eyes, having

ignored the timely warning to wear eye protection, then you ***must*** immediately wash them out with copious amounts of water and consult the hospital urgently.

Visibility

A further problem concerns visibility and the blocking action of the acid. In order to see what is happening to the etch-resist copper pattern, it has to face upwards in the tray – yet dissolved copper accumulates on the board and slows down the etching process, necessitating constant gentle tilting of the tray or agitation with something delicate, such as a hen's feather in order to keep the debris afloat, but don't use anything likely to damage the delicate etch-resist pattern.

'Bubble etching' tanks, as supplied for small commercial and educational use, are arranged to hold the boards vertically, to allow the debris to fall off to the tank bottom. The air bubbles pumped through the warm acid solution improve the efficiency of the process by gentle agitation.

The easy way

Seno have devised a neat solution to the etching problem with their 'Etch in the Bag' etching kit. This consists of a long, tough, transparent plastic bag with two special full- width seals. The re-sealable bag contains FeCl pellets, which can be activated according to the instructions and the board immersed in it.

At first glance, it is easy to dismiss the device; it really doesn't look as if you've got a lot for your money. In use, however, the system works well.

Unfasten the clip or clips above the ferric chloride pellets and pour in 250ml of hot tap water. This should be measured with a jug. Replace one clip above the liquid level and gently work fingers on the outer surface of the bag to persuade the pellets to melt.

When this is done, slip your exposed and developed PCB into the open part of the bag above the clip, then slip the second clip on above the board to seal it inside. The bottom clip holding back the acid can now be released and the acid allowed to flood over the board.

Place the bag in a bowl of quite hot water to speed up the etching, while rocking the liquid back and forth over the board. It may take up to 10 minutes

It's in the bag!

The yellow clip seals the acid into the lower half of the bag and the developed board is placed into open top part. The second clip then seals the bag.

The middle clip is released, allowing the etchant acid to flood across the board

Here the bag is being rocked through a bowl of warm water, keeping the etchant moving speeds the etching process. To check progress, the acid is drained by gravity into the lower half of the bag as the board is kept near the top. After etching is complete, the central clip is refitted, the upper clip released and the board washed with clean water before removal

to complete. It isn't hard to see through the transparent bag during the etching process, and then the board can be removed. All these actions being accomplished without bringing your fingers or your clothes into contact with the acid; although I very strongly recommend you follow the points about protection of hands and clothes – nothing is 100% accident-proof).

With the acid resealed in the bottom end of the bag, the top clip may be released and the open section washed out carefully with water, then the board can be removed. When all etching is finished a powder additive supplied with the kit can be poured into the bag. This converts the acid into a harmless solid for easy disposal. The kit as supplied is claimed to be good for the etching of 10 eurocard sized boards (160mm × 100mm) but remember that once activated, there is a limit to the life of the acid whether used or not.

Of course, there is nothing to stop you refilling your bag with fresh FeCl pellets, once the existing acid is exhausted.

7. Finishing touches

Cleaning of the board can now be easily carried out using Seno SN 120 resist stripper. This removes all traces of the unexposed photo-resist from the etched board. Alternatively, fine-grade wire wool can be used with care.

Bright, freshly exposed copper won't stay chemically clean for very long. Oxidation soon sets in (especially where fingers come into contact, another good reason for wearing latex gloves) and this initially almost invisible corrosion can and does cause problems with soldering.

The board can be thoroughly cleaned with the Seno SN130 deoxidation applicator, and then, to prevent further oxidation, immediately coated with Seno's SN140 flux applicator/lacquer, which provides a protective layer to prevent oxidation and also acts as an excellent solder flux.

The completed board is now ready for drilling and the mounting of components. To aid this, you might wish to glue a paper print of the top component layout onto the plain side of the board, as described earlier, to assist both in identification and location of components.

The trouble with acid

Making PCBs is an involved process with numerous stages, each one of which in the past potentially gave rise to problems that caused failure. Etching is especially problematic: all acid is quite unpleasant stuff to use and most often, for home use at least, iron (III) chloride, very commonly referred to as ferric chloride (FeCl) is used in one form or another because it is relatively safe to handle, given due care. Other acids may be used for etching PCB copper, though FeCl is the most well known and certainly the cheapest.

If you do opt to go it on your own, this can be purchased in dry pellet or crystalline form, which must be dissolved in water in suitable proportions to make the useable etchant, but it is also available in liquid form to dilute to requirements. Though not highly toxic, like any acid it ***MUST*** be handled with due respect.

The acid is exhausted when the colour of the liquid changes from the initial (fresh) red-brown through a muddy brown to dark green, with a black precipitate. Spent FeCl has to be either neutralised with a suitable agent or disposed of in a proper manner as described by the suppliers or your local authority. It should not simply be poured down the nearest drain.

It can be easily neutralised at home for safe disposal by adding calcium carbonate (whiting) or sodium bicarbonate (washing soda). Or set it into an inert solid mass by adding plaster of Paris before sending to landfill.

Avoid the fumes

FeCl gives off fumes when heated and these are definitely best avoided. If you are in the least bit asthmatic or have lung problems, **wear a face mask**. The acid is also said to be harmful when in contact with the skin, dangerous if swallowed (so obviously, don't) and can cause burns. Of course it can – it's acid.

Although these safety issues are valid, in practice ferric chloride is relatively innocuous stuff and I find the worst thing about it is that it leaves a red/brown stain seemingly anywhere and everywhere it can, a stain which is exceedingly difficult if not impossible to remove – and it is truly ruinous to clothing.

NOTICE BOARD

Seno and other useful PCB chemicals: ESR Electronic Components. **www.esr.co.uk**

PCB design packages: Labcenter Electronics. **www.labcenter.com**

Express SCH (schematic design) and Express PCB (layout design: **http:/Jexpresspcb.com/index.htm**

In conclusion

The Seno system and applicators neatly avoid the many problems inherent in the preparation, handling and disposal of the chemicals used to etch the board. I have some minor personal reservations about the ease of use of the photosensitive coating applicator, and it takes practice to achieve an even layer – but then, I haven't had totally reliable results from spray applicators either.

Producing your own coatings is never an easy thing to do, whatever method you choose. The Seno etch-in-a-bag kit is simple to use and effective, even though at first sight there's not a lot to it for the cost.

Using the techniques described in this article will make the home production of printed circuit boards (PCBs) a relatively straightforward process. Exposure of the sensitised board is perhaps the one area where ruinous errors can occur, but if you follow the guide, work steadily, and do not try to rush things, you should encounter no difficulty.

Be sure to read carefully the instructions provided with the chemicals and any of the Seno applicators you decide to use before making a start, know that your track pattern is accurate and is printed the essential dense black, time your UV exposure well and you can be confident of success. ***EPE***

Smart Meters For Smart Grids

TechnoTalk

Mark Nelson

Can electronics tame our soaring energy bills? With massive investment in smart grids and intelligent metering, the answer could be 'yes'. Mark Nelson investigates how this dream might come true.

It's 17 October 1956, and the Queen has today opened the world's first full-scale nuclear power station, at Calder Hall in Cumberland, not far from Windscale and Sellafield. The opening ceremony, attended by scientists and statesmen from almost 40 countries, is an upbeat affair, with promises of electricity generation too cheap to be worth metering and giving Britain a head start in what will become a large and increasingly important global industry.

Fast forward half a century to October 2009, when OFGEM, the UK energy watchdog, warned that British households could see a 60 per cent increase in energy bills in the next seven years. Consumers face potentially steep price rises in their gas and electricity bills as supplies became more volatile. In the cheapest of its four scenarios, OFGEM saw a rates rise of 14% by 2020, a result of slow economic recovery and global green stimulus packages, while bills could rocket a frightening 60% by 2016 if wholesale gas prices rise as a result of resurgent global economies competing for energy resources.

Smart solution

'Not true,' retorted the Department of Energy and Climate Change, but only because if energy prices reach this level, domestic consumption will fall as a result of smart metering. So it's time to look at the power industry's solution of smart meters, smart grids and superconductors. Don't hold your breath though; the power company changed my electricity meter last month and the only smart feature in it is a liquid crystal display replacing the revolving dials of the old meter.

So what is the smart grid? Also known as the 'intelligent grid', this phrase is shorthand for using digital technology to control consumption and facilitate localised energy production. In a moment we'll see how this can work, but first it's important to understand why this is so important.

Currently, our use of electric power and power generation is frankly profligate, as Steve Holliday, chief executive of National Grid, told the *London Evening Standard*. 'People are waking up to the fact that plasma TVs eat three times as much energy as LCD tellies,' he stated, while stoking up air conditioning units and fans in every office whenever there's a minor heatwave doesn't help.

Another thing that doesn't help is the crazy way our power stations churn out energy round the clock, regardless of demand levels. As energy analyst Walt Paterson states, the root cause of our waste of electricity is that we produce more than we need. Because mains electricity cannot be stored (unlike other utilities such as water or gas), it has to be generated at the time it is used. Our power stations generate for the maximum load expected, even though for most of the day, consumers' needs are below this output level.

Smart grid dissected

So what can a smart grid do? Gurpreet Gujral, research analyst with brokers Ambrian Partners, has a clear explanation. 'The smart grid is able to integrate any device that consumes, generates or controls power,' he explains. 'This modernised grid will accommodate intermittent energy generation using energy storage technologies and digital sensors (to regulate supply). We see a move away from large-scale centralised power sources towards smaller, low-carbon power sources, located closer to points of consumption.'

'As the make-up of the grid is reformed, a new ecosystem is created, with customers having greater choice of energy consumption patterns and pricing, the capacity to integrate renewable energy and other energy generation sources cost efficiently, and (to) deliver energy with increasing reliability and less carbon emissions.'

Smart metering

According to Alistair Morfey, technology director at Cambridge Consultants and leader of the company's smart metering business. 'Smart metering is crucial in the effort to make future energy savings and to tackle climate change. According to the Energy Saving Trust, smart meters can help consumers reduce their carbon emissions by 5% to 10%. If the UK as a whole adopted smart meters and reduced energy usage by 5%, this would save £1.2 billion a year on bills and 7.4 million tonnes of CO2 emissions.'

'The UK government committed in May 2009 to install smart meters in all 26 million homes by 2020, but even if roll-out begins in 2013, which is now the earliest realistic date, there will need to be at least 70,000 smart meter installations per week. Scale this up across Europe and it becomes clear that the debate about communications isn't going to be resolved in time.'

Morfey's company has developed a new low-power, low-cost, open communications standard known as the Universal Metering Interface or UMI. 'Communications standards are vital to enable smart energy appliances to talk to the meter and the grid, but the RF interfaces which the Home Area Network (HAN) and Wide Area Network (WAN) will use have not yet been selected', continues Morfey.

UMI is an ultra-low-power, low-cost and highly defined board-to-board wired interface, which will allow standard HAN (eg ZigBee or Wireless M-Bus) or WAN (eg GPRS) communications modules to be added to any metering product. By deploying UMI, says Morfey, manufacturers of all these intelligent energy saving devices can now start to roll them out to homes and energy suppliers around the world, while they are still waiting for communications interfaces to be agreed.

Superconductor solution

Superconductors are the maverick 'get out of jail' card for the electricity supply industry. The 'next big thing' they are not, but they might just be in a decade or two's time. Being near-perfect conductors of electricity, superconductors suffer nearly no electrical energy loss.

Very much blue-skies technology, they would replace traditional copper wire for electricity transmission, with the bonus of preventing power surges and blackouts, also minimising voltage drop on power lines from remote or offshore wind farms. Right now, superconductors work only at low temperatures, but it is estimated that the cost of refrigerating cables would absorb only half of the energy saved by reducing resistive loss in transmission cables.

'Superconductors are our business,' states the innovative German company Zenergy Power. The company is focused on the commercialisation of a number of new energy-efficient applications and is the first company in the world to provide industrial-scale commercial superconductor applications. Contrary to popular belief, says Zenergy, temperatures close to absolute zero are not essential to producing superconductive properties in some materials. Groundbreaking scientific research showed that certain ceramics become superconductive at 'higher' temperatures of around –150°C (123 Kelvin). This research was awarded a Nobel Prize for physics in 1987.

Cooling high-temperature superconductors (HTS) to their operating temperature is becoming easier and less costly, opening up a wide range of possibilities for technical HTS applications. In fact, Zenergy claims to have turned HTS wire into a product offering an economy that is superior to copper wire in many application areas. Unfortunately, nobody has yet discovered a room-temperature superconductor, but this is still the goal of researchers. You can read more about superconductors on Wikipedia (**http://en.wikipedia.org/wiki/Superconductivity**) and (**http://en.wikipedia.org/wiki/Electric_power_transmission#Superconducting_cables**).

A UV LIGHTBOX FOR MAKING PC BOARDS

Even though EPE publishes most PC board patterns and/ or has them available for download, making your own PC boards has for many been put in the 'too hard' basket. Here's one reader's way of producing commercial-quality PC boards at home.

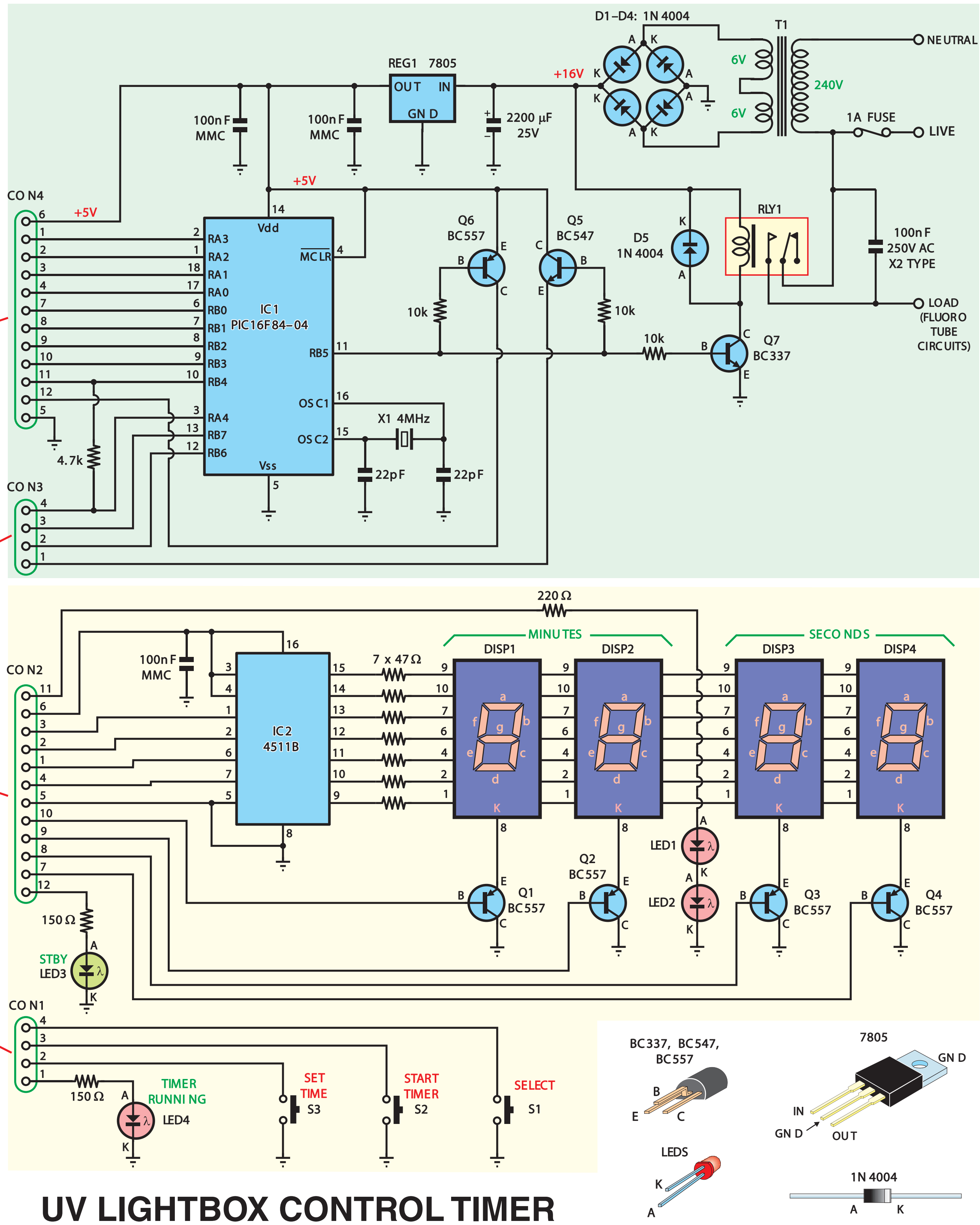
by Robert Scott

I **HAVE** been using Autotrax* 1.61 to design PC boards for my own creations for a few years now, ever since it became available at the right price (free!). Before that, I used Easytrax*, and way in the past I used rub-down tapes and pads.

That at least got me a PC board artwork. Now the challenge was to convert that to a PC board.

I tried using 'PressnPeel', a photo-sensitive film which transfers a toner direct to the PC board surface using a hot iron. This then acts as the resist for etching. However, despite the glowing reports I've seen on this product on the 'net, I found it had its limitations.

First, the blank PC board must be extremely clean for the toner image on the film to stick to it. Second, if the PC board artwork is quite a bit



UV LIGHTBOX CONTROL TIMER

Fig.1: the lightbox controller is built on two PC boards, and note that this circuit diagram is split in two, each part containing the contents of one of the boards. They are joined by two short cables, one 4-way and one 12-way, which plug into connectors 1/3 and 2/4 respectively.

larger than the iron, then it is hard to get the blank board up to the correct temperature all over for the toner to stick again.

Quite often you would pull away the film only to be left with a result where, Dalo pen in hand, you would have to repair the pattern as best you could.

It wasn't a very satisfactory situation, and to make matters worse, PressnPeel at a retail level adds quite a lot to the finished board cost.

Pre-coated boards

It is best to use positive acting photo-resist coated PC board. The coated PC boards are available in both SRBP and fiberglass, single or double-sided and in a variety of sizes.

The developing solution for this resist appears to be just plain old sodium hydroxide (NaOH; caustic soda), it is actually sodium metasilicate, mixed at 50g per litre of water. The good news is that I have heard sodium hydroxide works just as well. The bad news is that I have not been able to get sodium hydroxide anywhere, so I cannot verify if the above is true.

We can confirm that properly diluted sodium hydroxide will develop photo-resist coated boards perfectly. Too strong a solution and the whole image washes straight off. Too weak and nothing happens. Experimentation is a wonderful teacher – Ed.

OK, with the availability of the blank board and suitable UV lamps, the next step was finding a way to transfer the computer-generated PC board pattern to a transparency, through which the coated blank boards could be exposed. The idea is to have as high a contrast as possible – black blacks and clear 'whites'.

The problem with most printers, especially printing onto transparency film (eg, overhead projector film) is that the blacks are anything but. Hold one up to the light and you'll see what I mean.

If you are very accurate, to some degree this can be alleviated by using two sheets. I get very good results from two toner-coated transparencies from a laser printer stuck together with thin double-sided tape. I haven't tried inkjet transparencies, or even know if this is possible with inkjet. I find a good HP or Canon laser printer does the job admirably.

Editor's note: inkjet prints can be just as good as, if not better than laser prints. However, the problem of non-black blacks still exists. Incidentally, great results can be achieved by printing onto plain 'bond' paper – with an appropriate increase in exposure time.

Exposing PC boards

Coated boards are exposed by shining UV light through the artwork transparency. The clear part of the transparency 'softens' the emulsion on the PC board, which is then 'developed' away with sodium hydroxide solution.

Two problems exist. One is to keep the PC board pattern transparency in intimate contact with the board so that there is no light 'scatter', causing break-up of tracks. Even the thickness of the film itself can cause problems, so the image on the film should always be on the PC board side, ie, 'emulsion to emulsion.'

The second problem is to keep the amount of UV (ultraviolet) light exposure constant in both time and strength, so that results are consistent.

Various methods of exposure have been tried over the years – including using the very high UV content of sunlight. But this highlights problem two – the sun's strength varies according to time of day, cloud cover, latitude and atmospheric pollution levels.

The answer is to use a dedicated 'lightbox'. Using a timer, the exposure can be set, and with pressure applied to the transparency, the two parts can be held together properly.

I decided to see if a lightbox project was feasible. So, the first thing to do was check the net!

There appeared to be a lot of information, but only one website with anything like what I was looking for. It consisted of a PIC16F84 programmed as a timer with a basic circuit displaying on 7-segment displays. While it held promise, I believed that with a redesign of the firmware for the PIC, and particularly the hardware, I could make it much better.

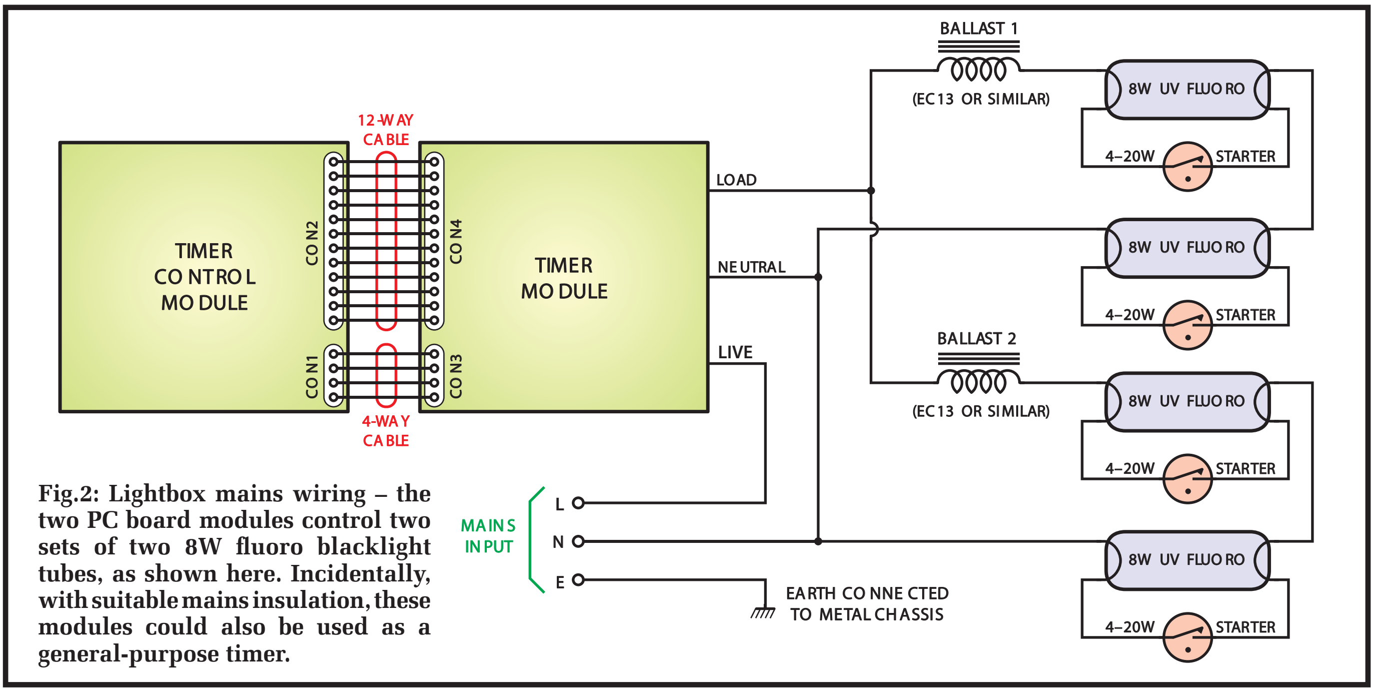


Fig.2: Lightbox mains wiring – the two PC board modules control two sets of two 8W fluoro blacklight tubes, as shown here. Incidentally, with suitable mains insulation, these modules could also be used as a general-purpose timer.

Outline of the project

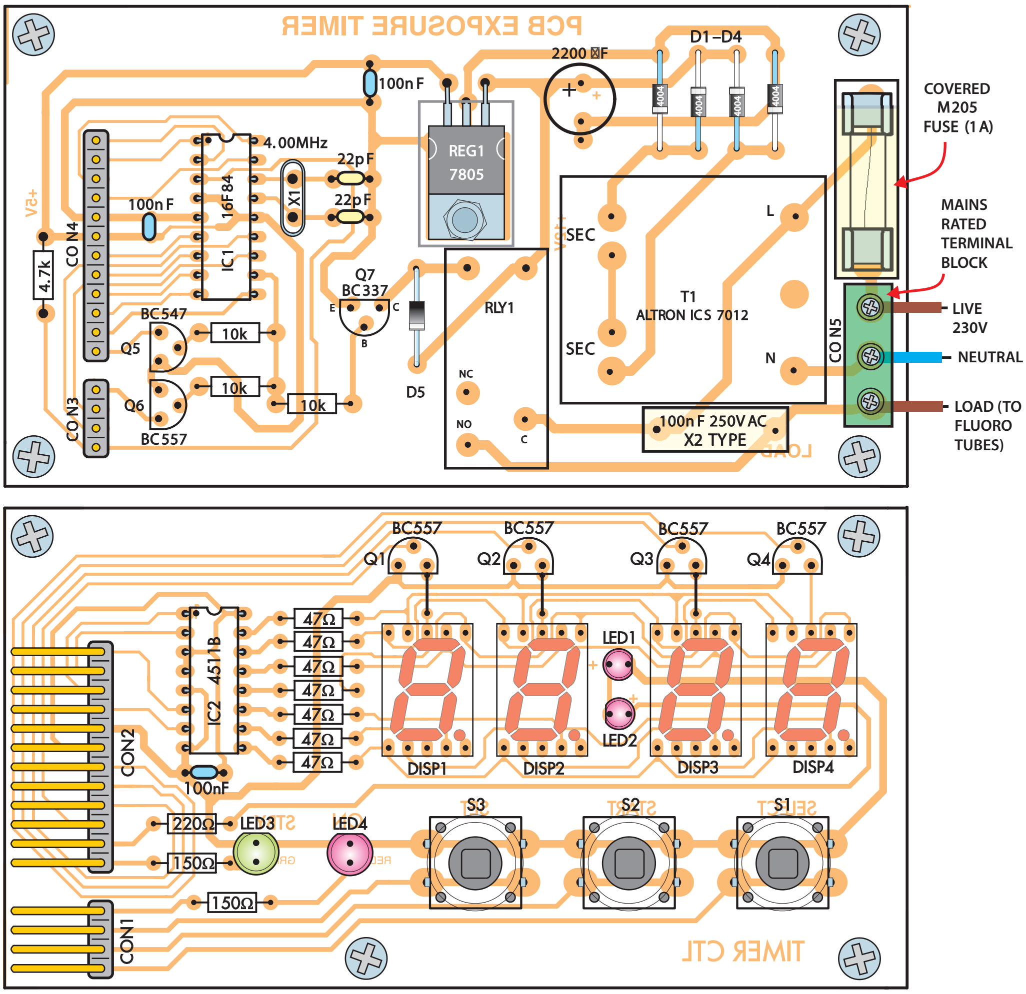
The electronics side of the project consists of two PC boards, each 120mm × 64mm. One is for the timer lamp control and power supply, the other the timer control and display panel.

One of these is mounted on stand-offs on the underside of a folded aluminium chassis, which also contains the fluorescent tube ballasts and starters. The other is mounted on the side of (and through) the lightbox, so that its LED displays and setting pushbuttons are all accessible and viewable from outside the box.

On the top side of the chassis are mounted the eight 'tombstones', which hold four 8W NEC fluorescent 'blacklight' (UV) tubes. These are not like the deep purple (almost black) blacklight tubes you see in clubs and discos. Instead, these are described as 'actinic blue' and appear white when off, but are very strong in UV as well as visible blue light when on.

This chassis is secured by screws in a wooden box, outside dimensions 360mm × 120mm × 100mm, which has a 6mm glass pane located in a channel in the sides of the box, which places it about 25mm above the fluorescent tubes. There is a hinged lid on the box, which has a piece of 6mm foam covered with felt glued to its underside. When the lid is locked shut, the foam and felt force the PC board (and the transparency underneath it) hard against the glass pane.

This ensures that the blank board and the transparency have intimate contact with one another so that the image on the transparency accurately transfers to the blank PC board.



Figs 3 and 4: the component board overlays for the Exposure Controller (top) and the Display/Timer Controller (bottom). CON5 should be a mains-rated 3-way terminal block, as shown.

Light source

Fig.2 shows the wiring of the exposure lamps, ballasts and starters, under the control of the timer PC board.

Power is switched to the fluoro tubes via a mains-rated relay, under the control of the PIC and switching transistors.

The four UV tubes are arranged in two identical parallel circuits, as shown. Each one consists of two lamps, two starters and a ballast, all in series. The starters are the 4W to 20W (more sensitive) type, for the lower level currents involved with 8W tubes.

It's a little unusual to have two tubes share one ballast, so a word of explanation might be necessary.

When power is applied, both starters will arc and close due to the internal bimetallic strip. The tube heaters will heat up and the inductor (ballast) will build up a 50Hz varying magnetic field. When one of the starters cools down and opens, the magnetic field round the inductor will collapse causing a somewhat large EMF to be developed across the inductor. This will appear across the open starter and its associated tube.

The gas inside the tube will ionise and the tube will strike. Once any fluorescent tube strikes, the voltage dropped across it due to current flowing through it is much reduced. If the other starter then opens, induced EMF across the inductor again will strike the second tube.

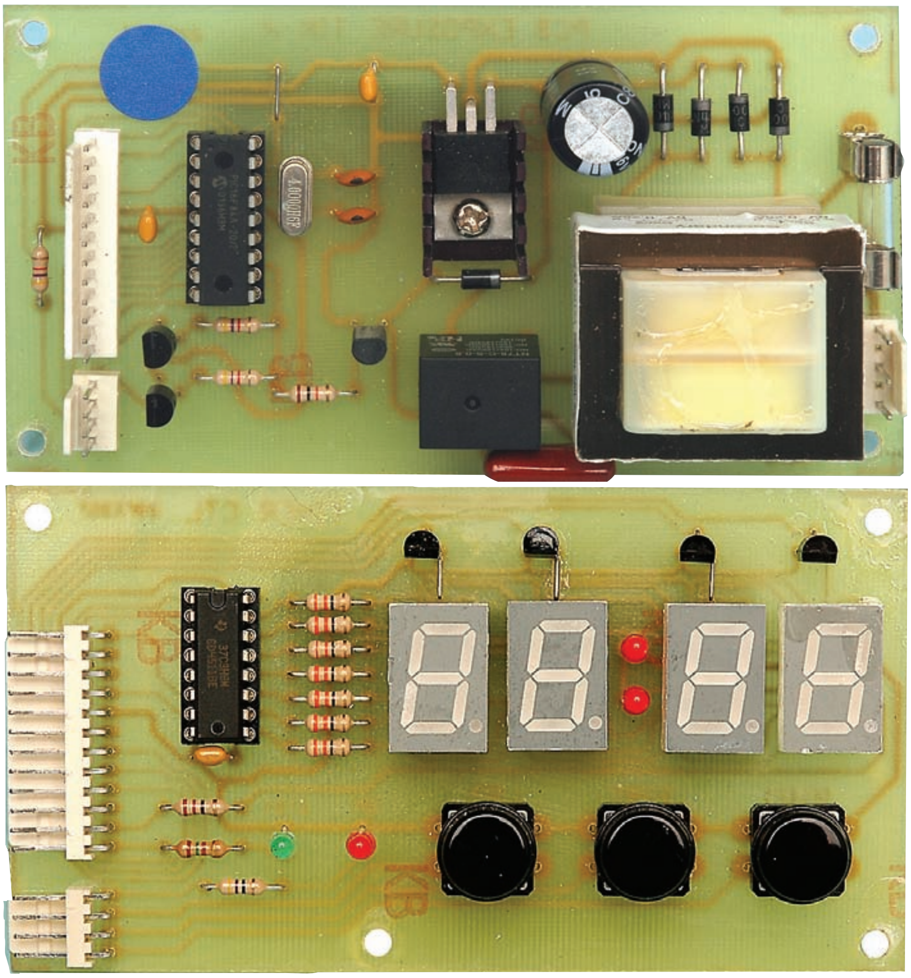
All this happens rather fast, and both tubes should be glowing within a second or so.

Sometimes, both starters open nearly simultaneously, and the start-up strikes occur together. This type of circuit is possible with low wattage tubes because the distance between tube heaters is small compared to say, a 36W standard lighting fluorescent light, and also the voltage drop is small.

The PC boards

Two PC boards are used, sharing functions between them.

The control/display PC board is connected to the timer board with 12-way and 4-way cables. I used these as it was easier to design and make single-sided PC boards to suit these than it was to make a double-sided board with a dual-in-line 16-pin plug. Because these are all on the low-voltage side of the circuit, ordinary



There are some differences between these photos and the final version – specifically, the mains connector, the fuse type, suppressor capacitor and the relay.

hookup wire or even rainbow cable can be used here.

The timer PC board is screwed to a small panel of 1mm aluminium with stand-off's. Cutouts and holes are required in the panel for the stand-off's, LEDs, 7-segment displays and pushbutton switches. This panel is then screwed to the left side of the lightbox with a cutout to suit.

Circuit details

Looking now at Figs. 1 and 2, power is supplied to the circuit via a 1A fuse, PC-mounted transformer, (230V to two 6V windings). Both 6V windings are connected in series, rectified and filtered, resulting in an unregulated DC supply of about 16V.

The unregulated supply is used to power the switching relay (RLY1) and is also fed to a 5V voltage regulator (REG1, 7805). This provides the timer with a 5V regulated supply.

Most of the timer operation is carried out by the programmed PIC16F84, so the circuit is not as complicated as it would otherwise be if hardware alone did the task.

The PIC's clock is set at 4MHz by crystal X1. IC1 pins 17,18,1,2 (RA0 to RA3) send multiplexed BCD data to the display board via CON4/CON2. Pin 6 to pin 9 (RB0 to RB3) send multiplexed data to transistors Q1 to Q4 (display drivers) on the display board, also via CON4/CON2. Pin 11, RB5, is normally held low in standby.

When the timer is counting down it goes high, biasing on transistor Q7 (BC337) which pulls in relay RLY1 (supplying power to the fluorescent tubes), at the same time biasing Q5 (BC547) on and Q6 (BC557) off. These in turn extinguish standby LED3 and turn on running LED4.

When the timer has completed the countdown, RB5 goes low, which turns off Q7 and turns on Q5 and Q6. Relay RL1 opens, the timer LED4 goes out and standby LED3 comes back on.

Pin 3, RA4, connects to the Select switch via CON3/CON1; a pull-up resistor is required here. Pin 12 and pin 13 (RB6, RB7) connect to the Set and Start switches (S3, S2) respectively.

Pin 10 (RB4) provides a positive pulse every second, while the timer is active, and this pulse is fed to two LEDs in series via a 220Ω resistor. These form a 'colon' between the minutes and seconds LCD digits.

Software

The software files are available for download via the *EPE* Library site, accessed via **www.epemag.com**. Pre-programmed PICs will also be available from Magenta Electronics – see their advert in this issue for contact details.

Making the chassis

Aluminium was chosen for the chassis as it is easy to work and some UV light will reflect from this, distributing the UV fairly well through the artwork. The chassis is bent in a 'U' shape, with holes and slots cut out for the various components.

The layout is shown in Fig.5, reproduced a little under half size. Ideally, the chassis should be bent to shape with a sheet metal folder, but good results can be had with 25mm angle iron and a sturdy vice.

The aluminium sheet size is 320 mm × 265mm and the sheet can be 1mm to 1.6 mm thick.

Making the Box

Once the chassis is made, the box can be made to fit. I made my box from 17mm plywood, 100mm high. A plywood lid was made to suit from the same material.

A sheet just over 600 × 470mm (to allow for saw cuts) will achieve minimum wastage. The two sides and two ends need a slot cut in them, about 7mm down from the top, to accommodate the glass plate.

There has to be a slot about 6mm down from the top of the box to fit the glass plate. This is best done with a router using a ¼-inch (6.5mm) bit. Cut the slot about the same depth (6.5mm). As you are not removing much wood, this can be done with one cut. The slot can also be cut with a circular saw if you are experienced enough – a router is better though and they can be obtained very cheaply these days.

Parts List – PC Board UV Lightbox

1 PC board, 120 × 64mm, code 765 (Exp Timer)
1 PC board, 120 × 64mm, code 766 (Timer/Display)
Available from the *EPE PCB Service*
1 aluminium sheet, 155 × 80mm × 1 to 1.5mm (for front panel) with label
1 aluminium sheet, 300 × 320mm (thickness 1 to 1.6mm) (for chassis)
1 230V to 12V (2×6V sec.) PC board mounting mains transformer
1 12V SPDT PC board-mounting relay, with mains-rated contacts
1 4MHz crystal (X1)
1 covered PC board-mounting, M205 fuseholder
1 1A M205 fuse
3 PC board-mounting pushbutton membrane switches
3 16-pin machine IC socket
1 18-pin machine IC socket
1 4-pin 90° PC board male socket
1 12-pin 90° PC board male socket
1 4-pin straight PC board male socket
1 12-pin straight PC board male socket
2 4-pin plugs
2 12-pin plugs
1 300mm length 4-wire cable (either rainbow cable or individual wires)
1 300mm length 12-wire cable (either rainbow cable or individual wires)
1 3-way mains-rated PC board-mounting terminal block
1 sheet 17mm plywood, 600 × 470mm and 17mm iron-on edge veneer
1 sheet 3mm plywood, 360 × 270mm (for base)
1 sheet 335 × 245 × 6mm clear glass (no flaws, scratches or tinting)
1 sheet 320 × 230 × 7mm foam plastic (high density if possible)
1 sheet 320 × 230mm felt
1 piece of red transparent plastic, 65 × 20 × 1.5mm (for display lens)
2 hinges for lid
4 rubber feet
4 8W UV (actinic blue) fluorescent tubes (eg, NEC blacklight FL8BL or similar)
8 miniature fluoro tube holders, type ST 268 (known as 'tombstones'),
4 fluorescent starter holders (HPM 390 or similar)
4 4W-20W fluorescent starters (Osram ST151 or similar)
2 13W fluorescent ballasts (EC13 or similar)
1 3-core mains lead fitted with 3-pin plug.
1 mains cord clamp
1 earth lead lug (crimp-on preferred)
Lengths of mains-rated hookup wire for fluoro tube, ballast and starter wiring

Semiconductors
1 PIC16F84-4 preprogrammed microcontroller (IC1)
1 4511 7-segment display driver (IC2)
1 7805 5V regulator (REG1) with U-shaped heatsink
5 BC557 or BC558 transistors (Q1 to Q4, Q6)
1 BC547 or BC548 transistor (Q5)
1 BC337 or BC338 transistor (Q7)
2 3mm red LEDs (LED1, LED2)
1 5mm green LED (LED3)
1 5mm red LED (LED4)
4 1N4004 1A rectifier diodes (D1 to D4)
4 0.5-inch 7-segment common cathode displays (DISP1 to 4)
(eg, Jaycar ZD1855 or similar)

Capacitors
1 2200μF 25V electrolytic
4 100nF monolithic
1 100nF 250V AC X2 TYPE
2 22pF ceramic

Resistors (0.5W, 1%)
3 10kΩ 1 4.7kΩ 1 220Ω 1 150Ω 8 47Ω

Electrical parts, including the miniature tube holders ('tombstones'), ballasts, etc are fairly common items available from (or ordered via) most electrical wholesalers.

The 8W 'blacklight' fluorescent tubes are not so common, but should also be available from major electrical wholesalers (even if on special order).

* Autotrax and Easytrax PC board layout software are available as free downloads from **www.altium.com/Community/Support/Downloads/**

As the smallest router bit I had was ¼-inch, the glass plate had to be the same thickness, ¼-inch or 6.5mm. This was a fortunate accident, because that's about the right thickness for stability, but not too thick to have to worry about UV absorption in the glass. It is important that the glass does not have any scratches or imperfections, as these will show up in your finished PC boards.

With the dimensions shown, the glass plate will be 6mm all round greater than the box internal, the chassis is 225mm wide by 320mm long, therefore it follows that the glass plate will be 237 x 332mm.

Of course, this all depends on your carpentry skills. I used iron-on veneer on the cut edges of plywood, and varnished the whole assembly. This makes the job attractive as well as functional. Ply was used rather than straight wood because it tends to be truer, so the pieces fit together better.

Below: the completed UV Lightbox with its plywood base removed. The second PC board is on the left side.

Is ultraviolet light dangerous?

From time to time, warnings appear about the dangers of UV light. Even as we go to press, UV tanning salons have been implicated in at least one recent death through melanoma (skin cancer). From the outset, let's state that staring at any light, especially intense light, is not good for the eyes. Very bright light, especially if strong in ultraviolet wavelengths in particular, is known to cause eye discomfort and damage.

UV types

Ultraviolet light is generally regarded as having a wavelength from about 200 to 400nm (nanometres). This is further divided into three sub-bands, UV-C, UV-B and UV-A.

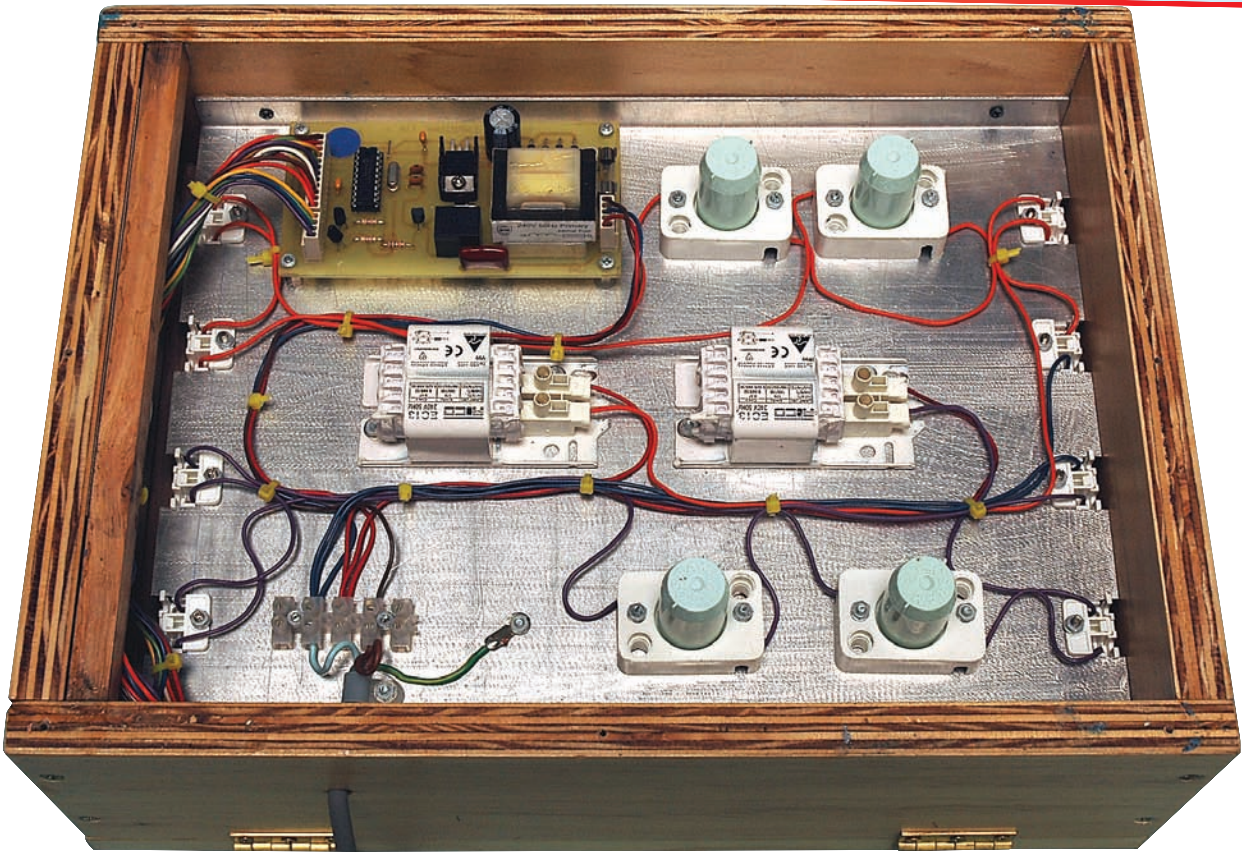
- UV-C (200-280nm) has the shortest wavelength and is often used as a germ killer or steriliser. It is regarded as dangerous stuff! Anything which emits UV-C usually has interlocks to prevent accidental exposure to the eyes or skin.
- UV-B (280-320nm) has a longer wavelength and is considered less dangerous, but exposure can redden and possibly burn the skin and may cause damage to the retina.
- UV-A has a longer wavelength again (320 to 400nm), it's considered less dangerous again.

Prolonged exposure to UV-B and perhaps to UV-A are acknowledged to cause skin damage and possibly promote skin cancers as well as eye damage. But the vast majority of references point to UV-B light as the bogey.

The NEC FL8BL blacklight lamps used in this project emit mostly UV-A, with a peak wavelength of 365nm (which also explains why there is so much visible blue light from them). They are in fact the same as (or similar to) the blue lamps used in bug zappers.

You ***must*** avoid long exposure, especially of the eyes, to any UV (or indeed any strong light). But the high wavelength of these tubes, their low power (all four combined are less than a single 36W fluorescent tube), the fact that there is a sheet of UV-absorbing glass above them, and the very intermittent nature of exposing PC boards, means that they are reasonably safe.

Having said all that, keep children away and don't let your teenage daughter/son use this as a mini face-tanning centre! If you are concerned, a mains-rated interlock switch (eg, a microswitch operated by the lid) could be fitted in series with the live wires going to the ballasts.



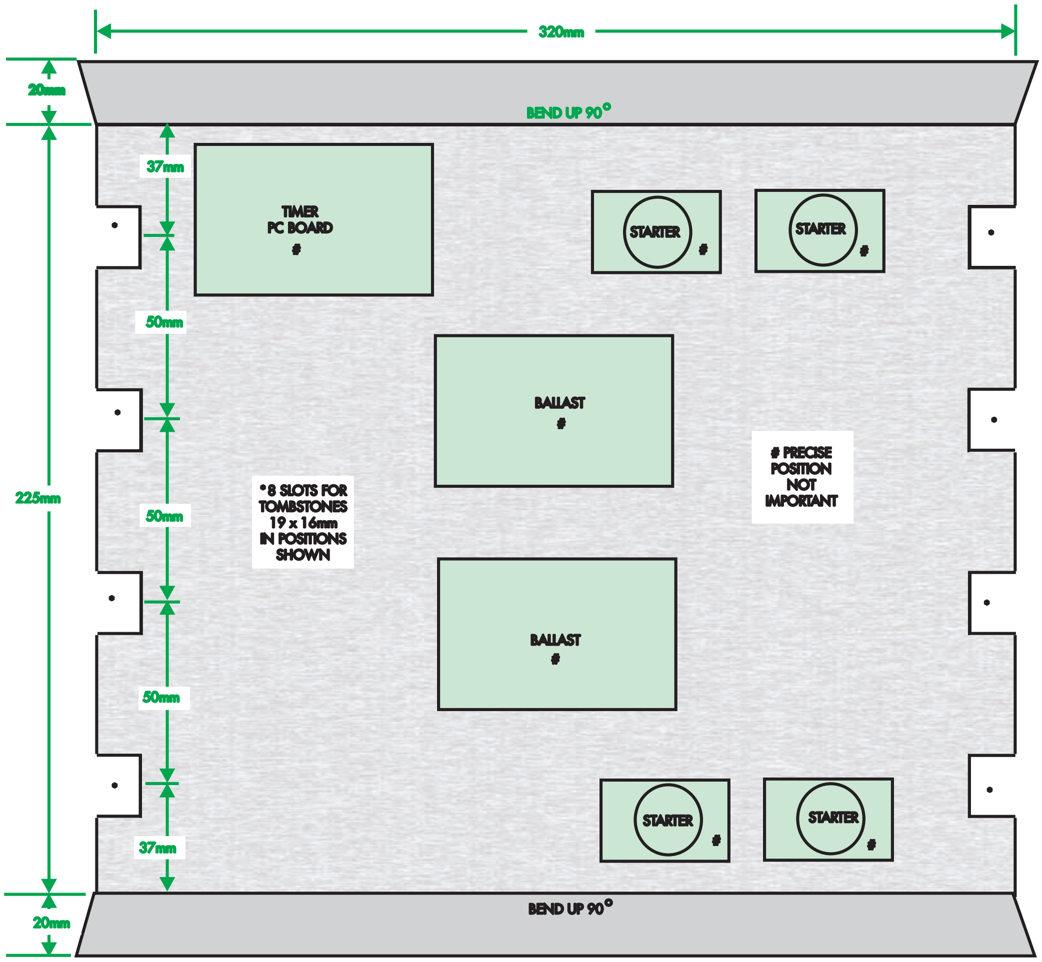


Fig. 5: here's how to fold and cut the aluminium chassis, looking from the underside. The only critical positions are the notches for the tombstones, which must of course line up with each other. The PC board, ballasts and starter holders can be placed in approximately the positions shown.

The lid is a single piece of plywood, the same size as the box, and again finished with iron-on veneer. It is attached to the box with two medium-sized hinges.

Inside the lid, a piece of 6mm high-density foam plastic, covered with self-adhesive felt on one side, was stuck into place with double-sided tape to fit into the space between the top of the box and the glass. Its size, 320mm × 230mm, allows it to clear the box edges as the lid is closed and press down hard on the blank PC board to hold it flat against the artwork.

Assembling the PC boards

The 'lightbox' circuit is assembled on two printed cicuit boards. The topside component layouts are shown in Fig.3 and Fig.4. These boards are available as a set from the *EPE PCB Service*, codes 765 (Exp Timer) and 766 (Timer/Display).

Commence construction of the PC boards by first soldering the three link wires on the Display board, followed by the resistors, IC socket, displays, sockets and capacitors.

The same order applies for the Timer/Power Supply board – the lowest profile components first, and highest last. 300mm lengths of 12-wire and 4-wire cables, using rainbow cable or single hookup wire lengths need to be made to connect the display/control board to the timer board.

Do not solder the LEDs into the display PC board yet.

Putting it all together

All components can now be fitted to the chassis as shown in Fig.6, and interwired as per the diagram. Be very careful in wiring the mains-carrying cable – that is, to all the fluorescent tube holders, starters and ballasts.

Mains wiring may be taken directly to the mains-rated block connector (CON5) on the timer PC board, with the switched Live connected to the rest of the circuit. Use single-core 10A lighting wire for wiring the lighting circuit. That's not because there are heavy currents involved, it's for the safety afforded by the cable's insulation.

Connections to the tombstones are achieved by pushing the stripped cable into the hole provided. The wires are locked into place by a spring loaded clamp, and once they are in it is difficult to pull them back out again, so try not to make mistakes. Make doubly and triply sure, however, that all strands of the wires have gone into the hole and none poke out to possibly short to the chassis.

Make sure you earth the chassis via the earth wire on the mains 3-core cable and plug.

The connections to the starter holders are achieved by a clamping screw.

A rectangular cutout will have to be made for the control /display board on its mounting plate, either in the front of the box, or as I have done, in the left side.

I have specified insulated stand-offs to mount the PC boards, but metal ones could be used, **except** for the one

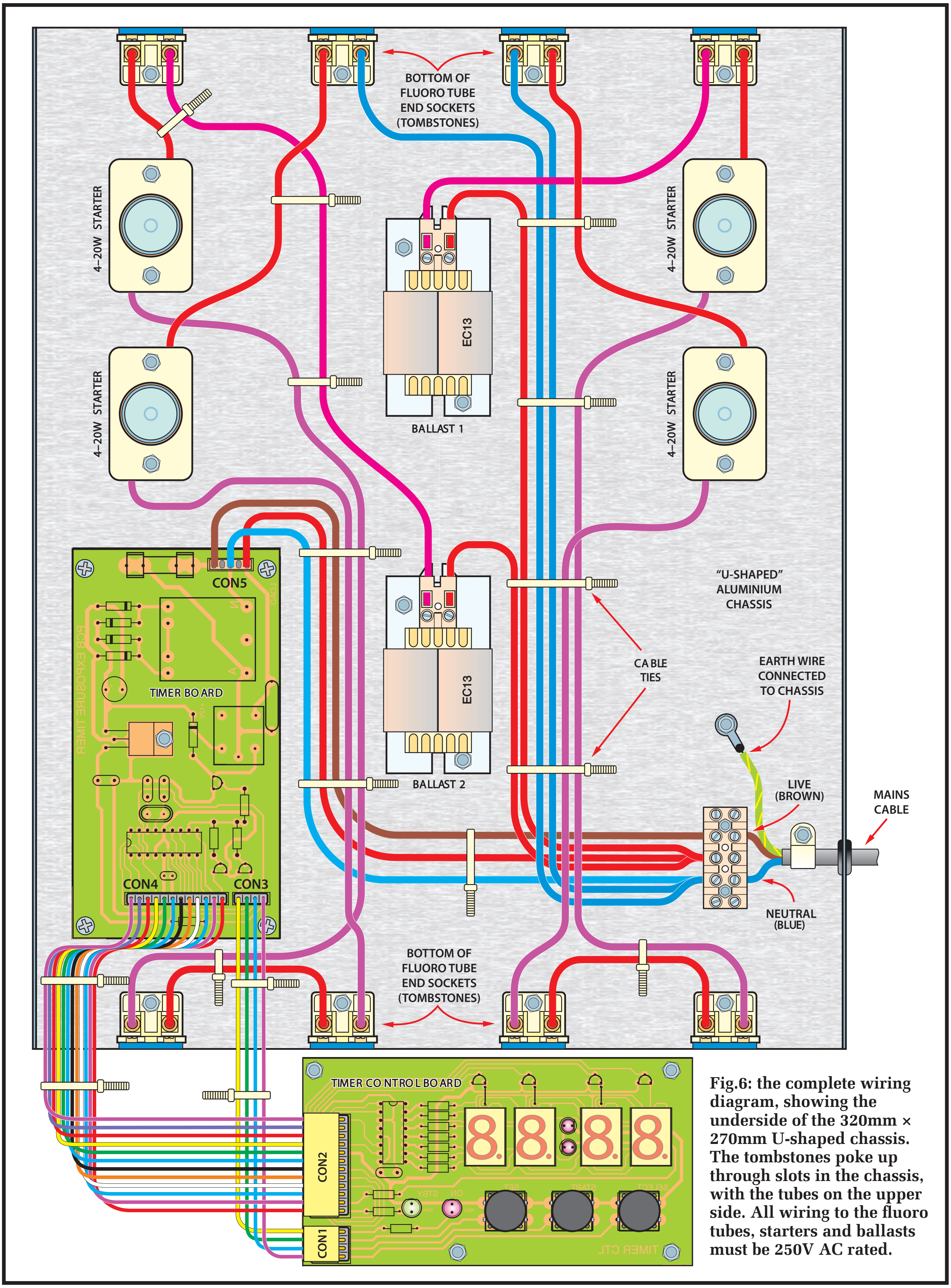


Fig.6: the complete wiring diagram, showing the underside of the 320mm × 270mm U-shaped chassis. The tombstones poke up through slots in the chassis, with the tubes on the upper side. All wiring to the fluoro tubes, starters and ballasts must be 250V AC rated.

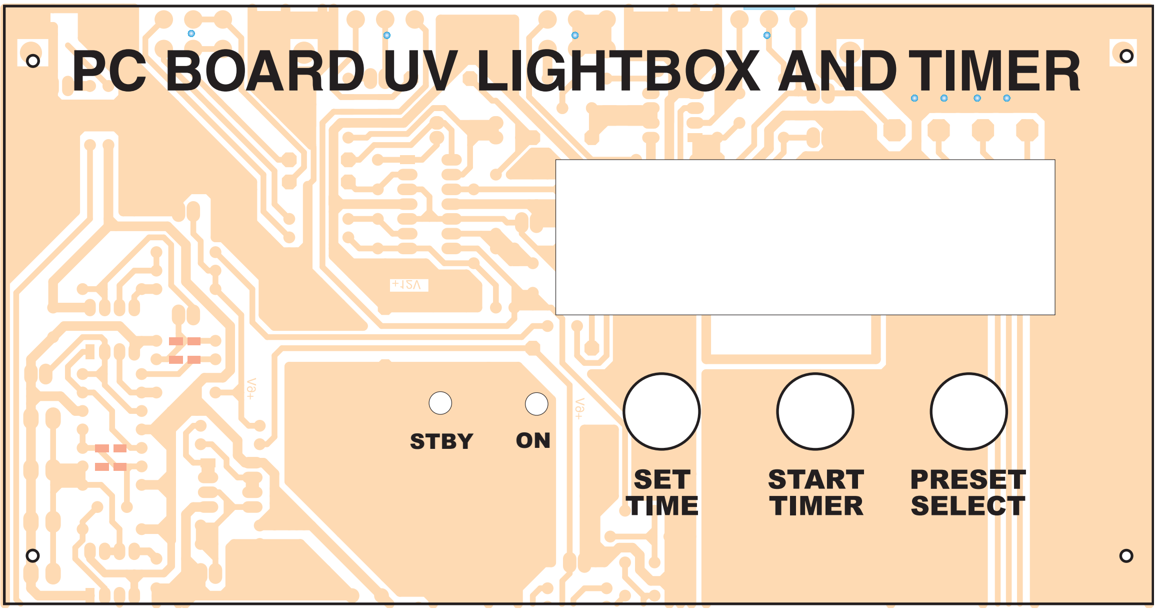


Fig.7: same-size artwork for the UV Lightbox front panel. Photocopy this and use as a template for drilling the holes in the aluminium sheet.

on the mains entry side of the timer/power supply board.

Display PC board

The display PC board is mounted on a small piece of 1mm (approx) aluminium, with holes drilled for the LEDs and switches, along with a cutout for the display.

A piece of 1mm reddish plastic was glued into the cutout as a protective screen for the 7-segment displays and seconds LEDs. Use a small quantity of slow setting epoxy for this. The 'five-minute' type sets too quickly and is not as strong.

Drill PC board mounting holes in the panel by placing a photocopy of the display board overlay (Fig.7) on the panel, lining up the 7-segment displays in the cut out and marking the centre of the holes to be drilled with a prick punch or scriber.

I used 2mm mounting screws, nuts and washers. The stand-offs should be 8mm to allow the push-button switches to sit proud of the front panel.

If you use 2mm screws, then you may have to make your own from 2mm brass tubing available from model aircraft stores. The 2mm screws don't stand out on the front panel as much as 3mm ones.

Countersunk screws could be used, and the front panel artwork fixed to the aluminium over the screw heads.

Testing.

It's best to test the timer out before you wire it in on the chassis. Plug the two boards together and wire the main board temporarily to the timer board. Do not plug the IC's in both boards just yet, that is the 4511 and the 16F84A. Make sure you have double checked everything first, especially the timer/power supply with its mains wiring.

In the interests of safety, you must cover the fuse and fuseholder with some insulation tape while testing. It's the only section of the top of the PC board that's likely to bite you – but if you contact it, it will do just that!

Switch on power, measure to see if you have approx +16V and a regulated +5V where marked on the power supply; also that +5V appears on pin 16 with respect to pin 8 on the 4511 socket and between pins 14 to 5 on the 16F84A socket. If all is well, and you have no burning smells, switch off and remove the mains plug from the power socket. Wait a short time for the electrolytic capacitors to discharge and insert the two ICs.

Reconnect and switch power back on. You should get a readout of 00:30 on the display board. The relay should not be energised and the green standby LED should be illuminated. If you do not have this, switch off and recheck your work.

Time check

If all is well, you can proceed to check the timer operation. Press the Start button, the green LED should go out and the red one should illuminate, at the same time the relay will energise and the display will begin to count down from 30 seconds to 0.

When the timer reaches 0, the relay will drop out, the red LED will extinguish and the green one will come back on. Pressing the start button again will bring back the 00:30 readout again.

Press the Select button and the display should change to a different time setting. Do this 15 times. There are 16 timer settings stored in EEPROM in the programmed 16F84A.

You can change any or all of these if you so desire by the doing the following: select a setting to change by pressing the select button until the display is reading the setting you want to change.

Press the Set button. The seconds will start flashing, incrementing one more every second, when the time in seconds is reading your requirement press Set again. The single minute digit will start to flash, incrementing as before; again, when your chosen time is reached press Set again. The tens of seconds will start to flash, incrementing as the single minute digit did.

Again, when your requirement is reached, press Set again. The timer will be set in EEPROM to your keyed-in time.

If you make a mistake then you will have to go through the procedure again. Usually, you will only need to do this once or twice.

If all is well with the timer check, the timer can now be wired into the chassis and the rest of the wiring completed. ***EPE***

PIC-based Flexitimer

★ Up to 54 different time periods.

★ Independent on/off periods ranging from one second to over three days.

★ Uses jumpers to set the timing periods

★ One-shot or continuous on/off cycling

By JIM ROWE

Here's a new and enhanced version of a very popular project: an easily-programmed low-cost electronic timer module. It's compact, easy to build and offers a choice of either a single on period or continuous on/off cycling with independently programmable periods.

IT'S CLEAR that many readers want a timer module that's low in cost, easy to program and offers great flexibility. For example, many people want independently programmable 'on' and 'off' times, as well as a considerably wider range of programmable times for each.

This new PIC-based Flexitimer fills the bill. It's cheap and easy to build, but this new unit offers 54 independently programmable on and off time periods. These periods range from one second up to to 90 hours (or 3.75 days!) and are easily programmed using jumper links.

In addition, the unit can operate in either of two timing modes – one-shot or continuous on/off cycling.

Circuit details

The complete circuit details of the PIC-based Flexitimer are shown in Fig.1. As you can see, the hardware is very simple. That's because all the timing 'work' is done by a firmware program running inside IC1, a low-cost PIC16F628A microcontroller.

The on and off timing periods are set by jumper shunts fitted to headers LK1 to LK6, while the timing mode (one-shot or continuous on/off cycling) is set via another jumper shunt that's either fitted to or left off LK7.

The firmware in IC1 reads the status of all of these links when it starts following power-up (or is reset after switch S1 is pressed). It then uses these settings to determine the timing.

In operation, the PIC16F628A (IC1) runs from an on-chip clock oscillator which is calibrated at the factory to have a frequency of 4MHz ±1%. As a result, this is also the timing accuracy of the Flexitimer (ie, ±1%), which should be close enough for the vast majority of timing applications.

During its 'on' timing periods, IC1 provides a logic high signal at pin 2 (RA3) which is used to turn on transistor Q1. Q1 in turn activates relay RLY1, to switch the control outputs. At the same time, LED1 turns on to indicate that the timer is currently in a 'relay ON' period.

Diode D7 protects transistor Q1 from damage due to inductive transients (back-EMF) when relay RLY1 is switched off. Diodes D1 to D6 are used to allow the firmware in IC1 to read links LK1 to LK6 via a multiplexing routine.

Power supply

Relay RLY1 and LED1 operate directly from the 12V DC input to the module, via polarity protection diode D8. By contrast, IC1 requires a supply voltage of +5V and this is derived from the +12V line via a 78L05 regulator (REG1).

The incoming supply to REG1 is filtered using a 470µF electrolytic capacitor, while a 100nF capacitor filters any noise on the +5V rail.

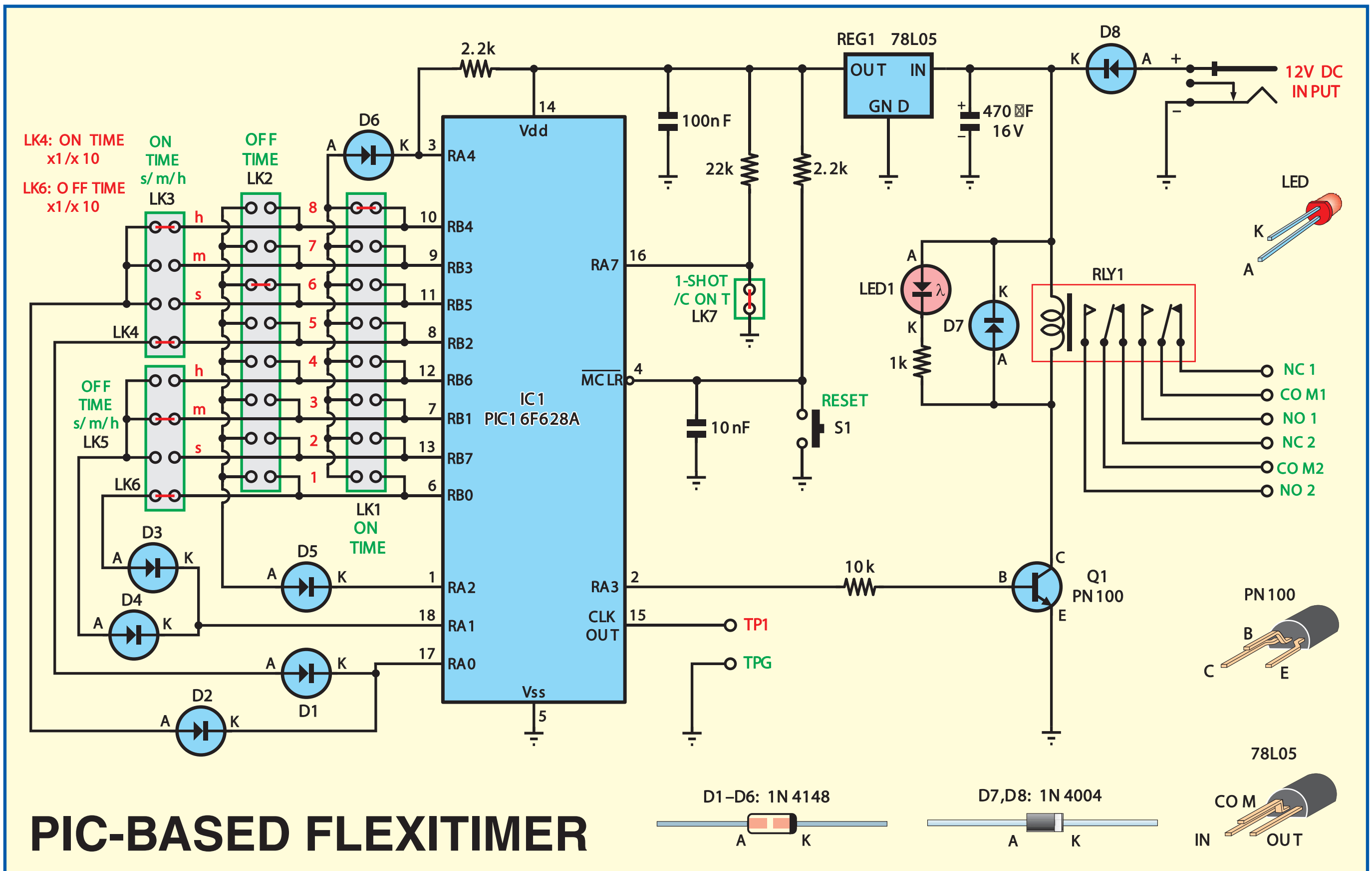


Fig.1: the circuit is based on PIC microcontroller IC1, which drives relay RLY1 via transistor Q1. Links LK1 to LK6 program the on and off times, while link LK7 sets the timing mode (either continuous or one-shot).

Software

The software files are available via the *EPE* Library site, accessed via **www.epemag.com**. Pre-programmed PICs will also be available from Magenta Electronics – see their advert in this issue for contact details.

Construction

All the parts used in the Flexitimer module fit on a small double-sided PC board, measuring 42mm × 102mm. This board is available from the *EPE PCB Service*, code 763.

The parts layout is shown in Fig.2. As you can see, the timing circuitry and programming links are on the lower half of the board, while the relay and its driver transistor (Q1) are on the upper half, along with REG1, the DC input connector and the output terminal blocks for the relay contacts.

The assembly is straightforward, but here's a suggested order:

1) Fit the five resistors, followed by the three capacitors. Note that the 10nF MKT capacitor goes at lower right, while the 100nF multilayer monolithic goes on the left, just below IC1. The 470µF electrolytic is at upper left, with its positive lead towards the bottom edge of the board.

2) Fit diodes D1 to D6, followed by D7 and D8. Be sure to orientate each diode correctly.

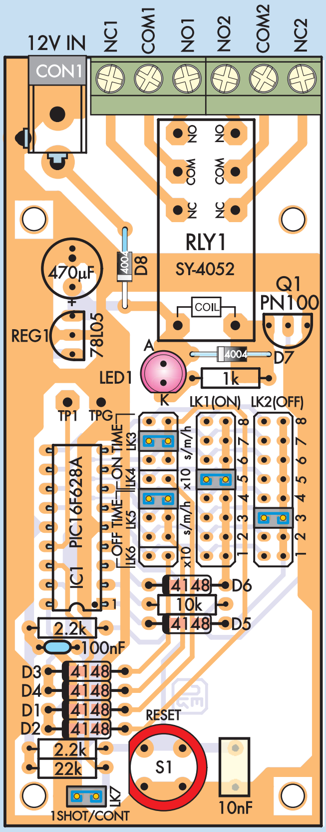
3) Install an 18-pin DIL socket for IC1, taking care to orientate it with its 'notch' end towards the bottom edge of the board.

4) Fit the three 8×2 DIL header strips to the board (for LK1, LK2 and LK3 to LK6). These may need to be cut from longer strips using a sharp hobby knife. Then install the remaining 1×2 header at lower left for LK7.

5) Fit two PC board terminal pins to the board in the positions marked TP1 and TPG.

Main Features and Specifications

- Operates from nominal 12V DC, with low current drain, <50mA when relay is on, <5mA when relay is off. Relay status indicated via red LED
- Outputs via the contacts of a DPDT relay (ie, 2x normally closed, 2x normally open), with 5A contact rating
- Jumper link selection for either a single ON timing period or continuous ON/OFF cycling
- Relay ON and OFF times separately programmed via jumper links for any of 54 different time periods: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90 seconds, minutes or hours
- Timing accuracy is ±1% at all settings
- Timer may be restarted at any time by pressing a reset pushbutton
- Module fits inside a standard UB3 utility box.



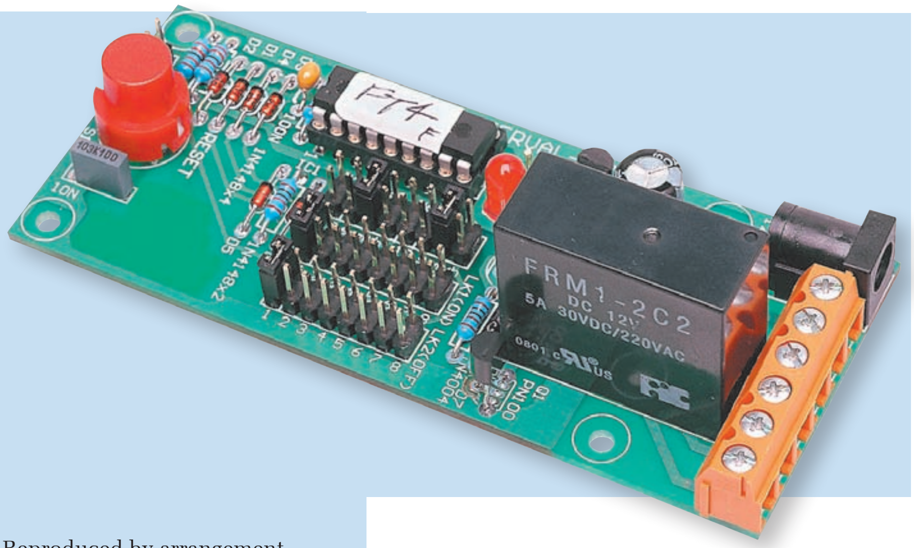


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Fig.2: install the parts on the PC board as shown in this overlay diagram and the accompanying photos. Table 2 shows how to set the various links, to program the timing periods and select the operating mode.

6) Install regulator REG1, transistor Q1 and LED1, again taking care with their orientation. Note that the boards supplied with the Jaycar kits will have multi-way pad 'footprints' for REG1 and Q1, allowing you to mount these devices with their leads unsplayed if that's how they are supplied.
However, take care to avoid solder bridges when soldering the leads, as some of these pads are very close together (splay the device leads if you prefer).

7) Fit the DC input connector (CON1) to the upper left of the board, then clip the two 3-way screw terminal blocks together and fit them in the adjacent position.

8) Install pushbutton switch S1 and relay RLY1. Take care with the orientation of the switch – it must be installed with its flat side to the left, as shown in Fig.2.

9) Complete the assembly by plugging microcontroller IC1 into its socket. Be sure to align its notched end with the notch in the socket – see Fig.2.

Setting the jumpers

With the board assembly completed, you now have to set the various jumpers to program the timer. As explained previously, these jumpers set the timing mode and the timing period (or periods) you want.

The easiest way to do this is by referring to the Jumper Settings Table.

The first jumper to set is LK7, which controls the timer's operating mode. If you fit a jumper shunt across LK7, the timer will operate in continuous on/off mode – ie, it will activate the relay for whatever ON time you program, then turn it off for whatever OFF time you program, then turn it on again for the programmed ON time and so on.

In other words, the relay will continuously toggle according to the programmed ON and OFF times.

Conversely, if you leave LK7 without a jumper shunt, the Flexitimer will operate in one-shot mode. This means that the relay will be turned on for the programmed ON time and will then be turned off again and remain off.

Having set LK7, you then set LK1, LK3 and LK4 for the required relay ON time. As shown in Table 2, the basic ON timing period is set by a jumper for LK1, while the units (seconds, minutes or hours) are set by a jumper for LK3 and the multiplier (×1 or ×10) by a jumper for LK4.

It's all quite intuitive, but note that to program LK1 for a time period of nine units, no jumper is fitted to any of the eight possible positions.

To illustrate this by an example, the timer is programmed for an ON

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	22kΩ	red red orange brown	red red black red brown
❏	1	10kΩ	brown black orange brown	brown black black red brown
❏	2	2.2kΩ	red red red brown	red red black brown brown
❏	1	1kΩ	brown black red brown	brown black black brown brown

Table 2: Flexitimer Jumper Settings Table

RELAY ON PERIOD									RELAY OFF PERIOD								
Time	LK1 jumper positions								Time	LK2 jumper positions							
	1	2	3	4	5	6	7	8		1	2	3	4	5	6	7	8
1	✓								1	✓							
2		✓							2		✓						
3			✓						3			✓					
4				✓					4				✓				
5					✓				5					✓			
6						✓			6						✓		
7							✓		7							✓	
8								✓	8								✓
9									9								

On Time Units & Mult	LK4 & LK3 jumper positions				Off Time Units & Mult	LK6 & LK5 jumper positions			
	LK4 (x10)	LK3a (s)	LK3b (m)	LK3c (h)		LK6 (x10)	LK5a (s)	LK5b (m)	LK5c (h)
Seconds		✓			Seconds		✓		
Seconds x 10	✓	✓			Seconds x 10	✓	✓		
Minutes			✓		Minutes			✓	
Minutes x 10	✓		✓		Minutes x 10	✓		✓	
Hours				✓	Hours				✓
Hours x 10	✓			✓	Hours x 10	✓			✓

Timer Operating Mode (LK7)	
	Jumper In: Continuous On/Off Timing
	Jumper Out: One Timing Period (Relay On)

period of 90 seconds as follows: no jumper on any of the LK1 positions, a jumper on the first LK3 position (LK3a = seconds) and a jumper on LK4 (= ×10). Get the idea?

If no jumper shunt is fitted to LK7 to select the one-shot operating mode, there's no need to fit jumpers for LK2, LK5 or LK6, because the OFF timing period won't be used. Conversely, if a jumper is fitted across LK7 for continuous mode timing, you will have to set the LK2, LK5 and LK6 jumpers for the desired relay OFF period.

These are set the same way as LK1, LK3 and LK4. So, for a relay OFF period of, for example, 40 minutes, you'd fit a jumper in the '4' position for LK2, and also jumpers in the LK5b (minutes) and LK6 (×10) positions.

Checkout time

To check out your PIC-based Flexitimer for the first time, try setting it up with the jumpers for one-shot mode (ie, no jumper for LK7) and 60 seconds of ON time, ie, jumpers on the '6' position of LK1, on the LK3a position and on LK4.

That done, apply 12V DC to the Flexitimer. LED1 and the relay should immediately turn on and remain on for very close to 60 seconds. They should then turn off and stay off indefinitely, unless you press the Reset pushbutton (S1). If the Reset button is pressed, they should immediately be turned on for another 60 seconds before they go off again.

If this all works as expected, your Flexitimer is very likely to be working correctly and should now be ready for use. However, just to make sure, try setting it up for continuous mode by fitting LK7 with a jumper shunt and programming in an OFF period of, say, two minutes, ie, a jumper in the '2' position of LK2, a jumper across LK5b and no jumper on LK6.

Now press S1 again. This should initiate a continuous sequence, whereby LED1 and the relay are ON for 60 seconds, OFF for two minutes, ON for another 60 seconds, OFF for another two minutes, and so on.

If it doesn't work, check the frequency at 'test point' TP1 using a scope or frequency meter. You should get a reading that's very close to 1MHz. If not, check the soldered joints on the microcontroller's socket. *EPE*

Parts List

1 PC board, code 763 (double-sided), available from the *EPE PCB Service*, size 42mm × 102mm
1 DPDT 12V relay (Jaycar SY-4052)
1 PC-mount SPST pushbutton switch, red, (Jaycar SP-0720)
2 3-way PC-mount screw terminal blocks, 5.08mm or 5mm pitch
2 20×2 DIL jumper strips
7 jumper shunts
1 2.5mm PC-mount DC socket
1 18-pin DIL IC socket
2 PC board terminal pins

Semiconductors
1 PIC16F628A pre-programmed microcontroller (IC1)
1 78L05 +5V regulator (REG1)
1 PN100 *NPN* transistor (Q1)
1 5mm LED (LED1)
6 1N4148 diodes (D1-D6)
2 1N4004 diodes (D7-D8)

Capacitors
1 470µF 16V radial electrolytic
1 100nF multilayer ceramic
1 10nF MKT polyester

Resistors (0.25W 1% metal film)
1 22kΩ 2 2.2kΩ
1 10kΩ 1 1kΩ

Where to buy a kit

This project was developed by Jaycar Electronics and they own the copyright on the PC board. Kits will be available exclusively from Jaycar (Cat. KC-5464).

Ultra-LD 200W Power Amplifier

A new class-AB design with ThermalTrak power transistors

This new amplifier module produces high power at very low distortion. In fact, as far as we are aware, it is the lowest-distortion class-AB amplifier that has ever been published.

Part 1: By LEO SIMPSON and JOHN CLARKE

Specifications and performance

Output power: 200 watts RMS into 4Ω; 135 watts RMS into 8Ω

Frequency response at 1W: –3dB at 4Hz, –1dB at 50kHz (see Fig.4)

Input sensitivity: 1.26V RMS for 135W into 8Ω

Input impedance: ~12kΩ

Rated harmonic distortion: < 0.008% from 20Hz to 20kHz for 8Ω operation; typically < 0.001% (see Figs.5-8)

Signal-to-noise ratio: 122dB unweighted with respect to 135W into 8Ω (22Hz to 22kHz)

Damping factor: <170 with respect to 8Ω at 100Hz; <50 at 10kHz

Stability: unconditional

THE ULTRA-LD AMPLIFIER Module uses the new On Semiconductor ThermalTrak power transistors in a circuit that is largely based on our high-performance Class-A amplifier, which was featured in *EPE* from October 2008 to February 2009. The ThermalTrak transistors are a new version of the premium MJL3281A and MJL1302A, and have an integral diode for bias compensation. As a result, the circuit has no need for a quiescent current adjustment or a 'Vbe multiplier' transistor.

This is also our first amplifier module to use a double-sided PC board. Ostensibly, there is no reason to use a double-sided board for a relatively simple circuit such as this, especially as our previous single-sided amplifier boards have had few links. In fact, we have used the double-sided design to refine and simplify the external wiring to the PC board, which has been arranged to largely cancel the magnetic fields produced by the asymmetric currents drawn by each half of the class-B output stage. We provide more detail on this aspect later in this article.

Power output of the new module is on a par with previous designs, but uses a considerably simpler power supply.

Power output is 135W RMS into an 8Ω load and 200W into a 4Ω load for a typical harmonic distortion of less than 0.001%. This design has a signal-to-noise ratio of –122dB (unweighted) with respect to 135W into 8Ω. This is extremely quiet.

A look at the accompanying performance panel and the performance graphs will show that this is a truly exceptional amplifier, bettered only by the Class-A amplifier described in 2008/09. In fact, some of the distortion figures we have obtained are so low, around 0.0007% for operation into 8Ω loads, that we were amazed. We had expected this Class-AB amplifier to be better than anything we had published before – but not this good!

Design features

- Very low distortion
- No adjustment for quiescent current required
- Double-sided PC board simplifies wiring
- PC board topology cancels Class-B induced magnetic fields

Circuit description

Fig.1 shows the full circuit of the new amplifier. As already mentioned, the front end of the circuit (ie, all except the output stages) is based on the Class-A amplifier published in October 2008 and subsequent issues. While the general configuration was designed to optimise performance of the Class-A design, it provides similar benefits to Class-AB operation, such as low residual noise and excellent power supply rejection ratio (PSRR).

We have already mentioned that there is no need for a 'Vbe amplifier' stage and no quiescent current adjustment. Also, the complementary-feedback pair (CFP) power output stage of some common designs has been discarded in favour of a more conventional complementary-symmetry Darlington emitter follower stage.

So let's go through the circuit in detail. The input signal is coupled via a 47µF non-polarised (NP) electrolytic capacitor and 100Ω resistor to the base of transistor Q1. This is one of the input differential pair (ie, Q1 and Q2) using Toshiba 2SA970 PNP low-noise transistors, which are responsible for the very low residual noise of the amplifier. The 100Ω input resistor and 820pF capacitor constitute a low-pass filter with a –6dB/octave rolloff above 1.9MHz.

This is a much lower impedance network than our previous designs, in order to provide the lowest impedance for the signal source.

Both the bias resistor for Q1 and the series feedback resistor to the base of Q2 are set at 12kΩ, again to minimise source impedance and thereby, Johnson noise.

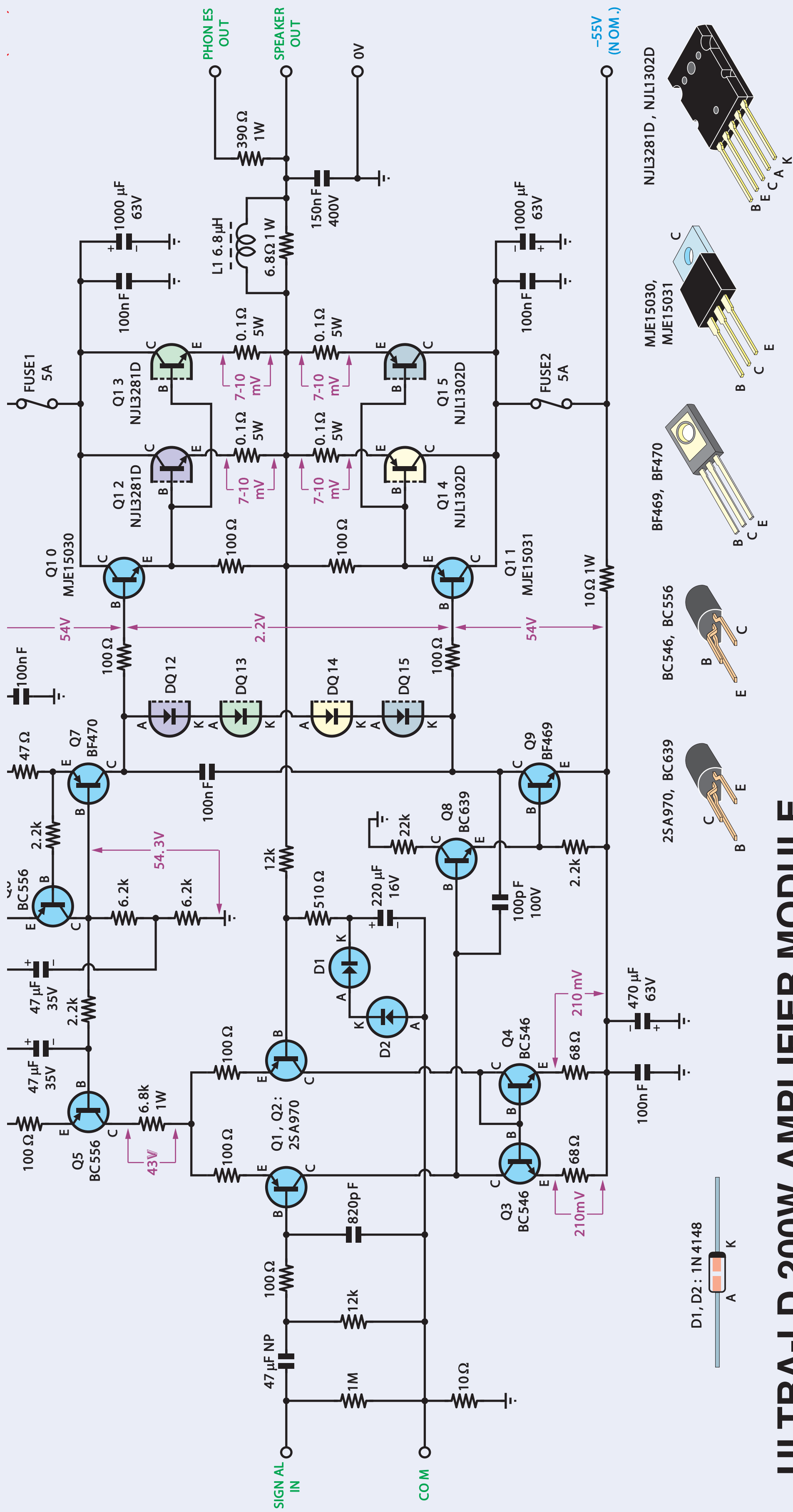
The gain of the amplifier is set by the ratio of the 12kΩ and 510Ω feedback resistors to a value of 24.5, while the low-frequency rolloff (–3dB) of the gain is set by the 220µF capacitor to 1.4Hz.

Feedback capacitors

Some readers may wonder why we used such large electrolytic capacitors in the input and feedback networks. The answer is that we are acting to eliminate any effects of capacitor distortion in the audio pass-band and as noted above, to minimise the source impedance 'seen' by the input transistors.

To explain this point, consider that the typical source impedance of a DVD or CD player is only a few hundred ohms. If we use a much smaller input capacitor, say 2.2µF, its impedance will be 1447Ω at 50Hz. This will only have a small effect on the frequency response, but represents a very large increase in the source impedance 'seen' by the input stage. By contrast, the 47µF input capacitor will have an impedance of only 67Ω.

Readers might also wonder why we have not used a non-polarised (NP) electrolytic for the 220µF capacitor in the feedback network, since this is normally preferable where the capacitor's operating voltage is extremely low. The answer is that an NP electrolytic could have been used, but its bulk is a problem and we wanted to minimise



ULTRA-LD 200W AMPLIFIER MODULE

Fig.1: the circuit employs the new ThermalTrak power transistors from On Semiconductor. These have an integral diode, which is used to control the quiescent current in the Class-B output stage. The four diodes are shown separately on this circuit (ie, DQ12, DQ13, DQ14 and DQ15) for clarity, but are actually integral with the output transistors, which have five connecting leads instead of three. Note that the various voltages marked on the circuit will vary according to the supply rails.

Parts List – Ultra-LD 200W Power Amplifier

1 double-sided PC board, code 767, available from the *EPE PCB Service*, size 135mm × 115mm
1 heatsink, size 200L × 75mmH × 46Dmm
4 M205 PC-mount fuse clips (F1,F2)
2 5A M205 fast-blow fuses
1 6.8μH air-cored inductor (L1) (or 1 20mm OD x 10mm ID × 8mm bobbin and 1.5m length of 1mm enamelled copper wire)
2 3-way PC-mount screw terminals, 5.08mm spacing (CON2, CON3)
1 2-way PC-mount screw terminals with 5.08mm spacing (CON1-CON3)
2 TO-220 mini heatsinks, 19 × 19 × 9.5mm
2 TO-220 silicone insulating washers
4 TO-264 ThermalTrak silicone insulating washers
2 transistor insulating bushes
4 M3 tapped × 9mm standoffs
6 M3 × 20mm screws
2 M3 × 10mm screws
8 M3 × 6mm screws
8 M3 nuts

Semiconductors
2 2SA970 *PNP* transistors (Q1, Q2)
2 BC546 *NPN* transistors (Q3,Q4)
2 BC556 *PNP* transistors (Q5,Q6)
1 BC639 *NPN* transistor (Q8)
1 BF470 *PNP* transistor (Q7)
1 BF469 *NPN* transistor (Q9)
1 MJE15030 *NPN* transistor (Q10)
1 MJE15031 *PNP* transistor (Q11)
2 NJL3281D *NPN* ThermalTrak transistors (Q12,Q13)
2 NJL13020D *PNP* ThermalTrak transistors (Q14,Q15)
2 1N4148 signal diodes (D1,D2)

Capacitors
2 1000μF 63V PC electrolytic
1 470μF 63V PC electrolytic
1 220μF 16V PC electrolytic
2 47μF 35V PC electrolytic
1 47μF NP electrolytic
1 150nF 400V MKT polyester
5 100nF 63V MKT polyester
1 820pF ceramic
1 100pF 100V ceramic

Resistors (0.25W, 1%)

1 1MΩ	8 100Ω
2 12kΩ	2 68Ω
1 22kΩ	1 47Ω
1 6.8kΩ 1W	1 6.8Ω 1W
2 6.2kΩ	1 10Ω
3 2.2kΩ	1 10Ω 1W
1 510Ω	4 0.1Ω 5W
1 390Ω 1W	2 0Ω

2 68Ω 5W (for testing)

Transistor quality

To ensure published performance, the 2SA970 low-noise transistors (Q1 and Q2) must be from Toshiba. Be wary of counterfeit parts, as reported by us in the past. All other transistors should be from reputable manufacturers, such as Philips (NXP Semiconductors), On Semiconductor and ST Microelectronics. This applies particularly to the MJE15030 and MJE15031 output driver transistors.

any extraneous signal pickup, which could happen with a physically larger capacitor.

Extraneous signal pickup is one of the unwanted side-effects of a much wider frequency response – the amplifier is more prone to EMI, and in the extreme case, to supersonic oscillation, if the wiring details are not duplicated exactly.

Diodes D1 and D2 are included across the 220μF feedback capacitor as insurance against possible damage if the amplifier suffers a fault; it pegs the output to the –55V rail. In this circumstance, the loudspeakers would be protected against damage by a loudspeaker protection module (such as that published in the *EPE*, December 2008 issue) but the 220μF capacitor would be left to suffer reverse current.

Note that we have used two diodes here instead of one, to ensure that there is no distortion due to the non-linear effects of a single diode junction at the maximum feedback signal level of about 1V peak.

Voltage amplifier stage

Most of the voltage gain of the amplifier is provided by Q9, which is fed via emitter follower Q8 from the collector of Q1. The emitter follower transistor is a BC639, which has higher ratings than the BC546 used for this function in the Class-A amplifier. It is used to buffer the collector of Q1, to minimise non-linearity.

Q9 is operated without an emitter resistor to maximise gain and its output voltage swing. We need to maximise voltage swing from the voltage amplifier stage in order to obtain the maximum power output from the output stages.

The collector loads for Q1 and Q2 are provided by current mirror transistors Q3 and Q4. Similarly, the collector load for Q9 is provided by a constant current load comprising transistors Q6 and Q7. Interestingly, the base bias voltage for constant current source Q5 is also set by Q6. Q5 is the constant current 'tail' for the input differential pair, and it sets the collector current through these transistors.

The reason for the rather complicated bias network for Q5, Q6 and Q7 is to produce a major improvement in the power supply rejection ratio (PSRR) of the amplifier. Similarly, the PSRR is improved by the bypass filter network consisting of the 10Ω 1W resistor and 470μF 63V capacitor in the negative supply rail.

Why is PSRR so important? Because this amplifier runs in class-B, it pulls large asymmetric currents, which can be 9A peak or more, from the positive and negative supply rails.

Let's explain this. When the positive half of the output stage (Q12 and Q13) conducts, the DC current drawn is effectively the positive half-wave of the signal waveform, ie, rectification takes place. Similarly, when the negative half of the output stage (Q14 and Q15) conducts, the DC current is the negative half wave of the signal.

So we have half-wave rectification ripple of the signal superimposed on the supply rails, as well as the 100Hz ripple from the power supply itself. And while the PSRR of an amplifier

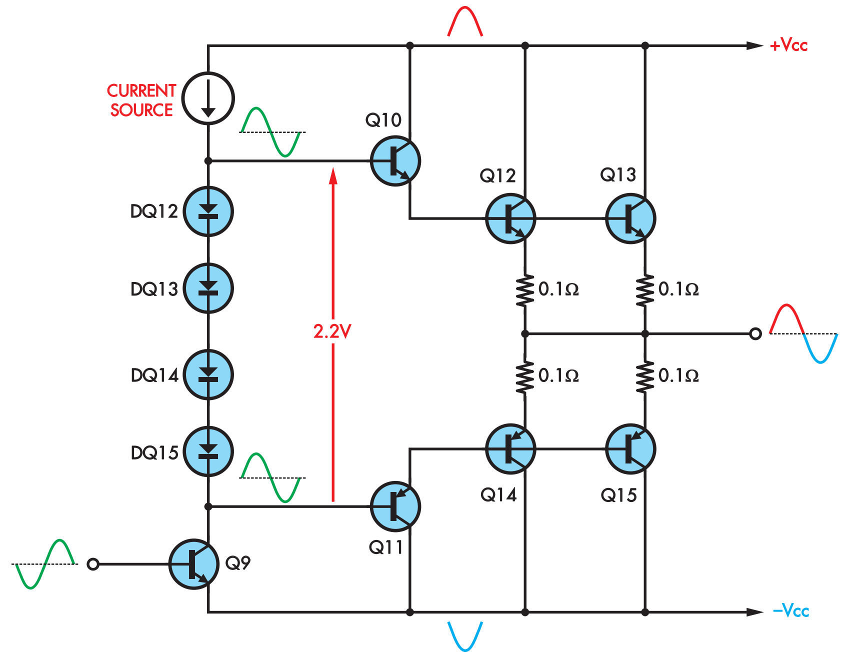


Fig.2: this schematic demonstrates how the four integrated diodes of the output transistors set the quiescent operating conditions of the Darlington emitter follower output stage. Note that the voltage drop across each diode is quite low at round 0.55V.

can be very high at low frequencies, it is always poorer at the high frequencies. So what happens is that these nasty ripple voltages inevitably get into the earlier stages of the amplifier and cause distortion, which is why we need to keep these ripple voltages to a minimum.

That is why we often employ separate regulated high-voltage supply rails for amplifiers. However, the extra filtering we employed in the Class-A amplifier (using techniques suggested by Douglas Self) now performs much the same function in this new Class-AB amplifier module so that we can dispense with the regulated supplies.

The scope grab on page 40 in this article gives a graphic demonstration of the signal rectification phenomenon we have just described. The centre (yellow) trace shows a 1kHz sinewave output signal from the amplifier at 100W into an 8Ω load. The top (red) trace shows the ripple on the positive supply.

Note the large 100Hz sawtooth component, which is ripple from the power supply. Superimposed on this is the half-wave rectified signal frequency at 1kHz. The bottom (blue) trace shows the same process on the negative supply rail.

The 100pF capacitor between the collector of Q9 and the base of Q8 sets the open-loop bandwidth of the amplifier. Since it is subject to the full output voltage swing of the voltage amplifier stage, it must have a rating of 100V or more.

Output stage

The output signal from the voltage amplifier stage Q9 is coupled to driver transistors Q10 and Q11 via 100Ω resistors. These protect Q7 and Q9 in the event of a short circuit to the amplifier output, which could possibly blow these transistors before the fuses blow. The 100Ω resistors also have a secondary function in acting as 'stopper' resistors to help prevent parasitic oscillation in the output stage.

WARNING!

High DC voltages (ie, ±55V) are present on this amplifier module when power is applied. **In particular, note that there is 110V DC between the two supply rails.** Do not touch the supply wiring (including the fuseholders) when the amplifier is operating, otherwise you could get a lethal shock.

As already mentioned, the output stage uses complementary Darlington transistor pairs. There are two reasons for this approach. First, we are using the highly linear ThermalTrak output transistors with their integral bias compensation diodes. To take advantage of these diodes we need to employ Darlington emitter followers, as will be explained in a moment.

Second, a CFP output stage does not give good current sharing between the paralleled output transistors. and we wanted this in order to make this new Ultra-LD amplifier suitable for delivering full power into 4Ω loads.

Bias compensation

With four Thermaltrak power transistors used in the output stage, we have four integrated diodes available for bias compensation. As shown on the circuit, the four diodes are connected in series between the collector of Q7 and the collector of Q9. Some readers may be aware that this arrangement, together with an adjustable series resistor, was a common method for setting the output quiescent current, before the 'Vbe multiplier' became the standard method over 30 years ago.

Now, for a given bias setting in any Class-B amplifier, the base-emitter voltage in the output transistors will drop with a rising temperature. So, as the output transistors heat up, they draw more current, which makes them hotter, and soon you have 'thermal runaway' and eventual transistor destruction.

Since the bias setting for the output stage transistors is set by the voltage drop across the four integrated diodes, there is little chance of thermal runaway. Not only are the diodes matched to the base-emitter junctions of the transistors, they are also on the same die (chip) so the tracking between the two is very close.

This is a great advantage over a Vbe multiplier transistor mounted on the heatsink because the latter arrangement inevitably has a considerable thermal lag, which can be as much as 30 minutes (depending on the size of the heatsink).

With the Thermaltrak transistors, we don't have to worry about thermal lag or runaway. The quiescent current settles quickly at switch-on. Thereafter, it can drift about, depending on the

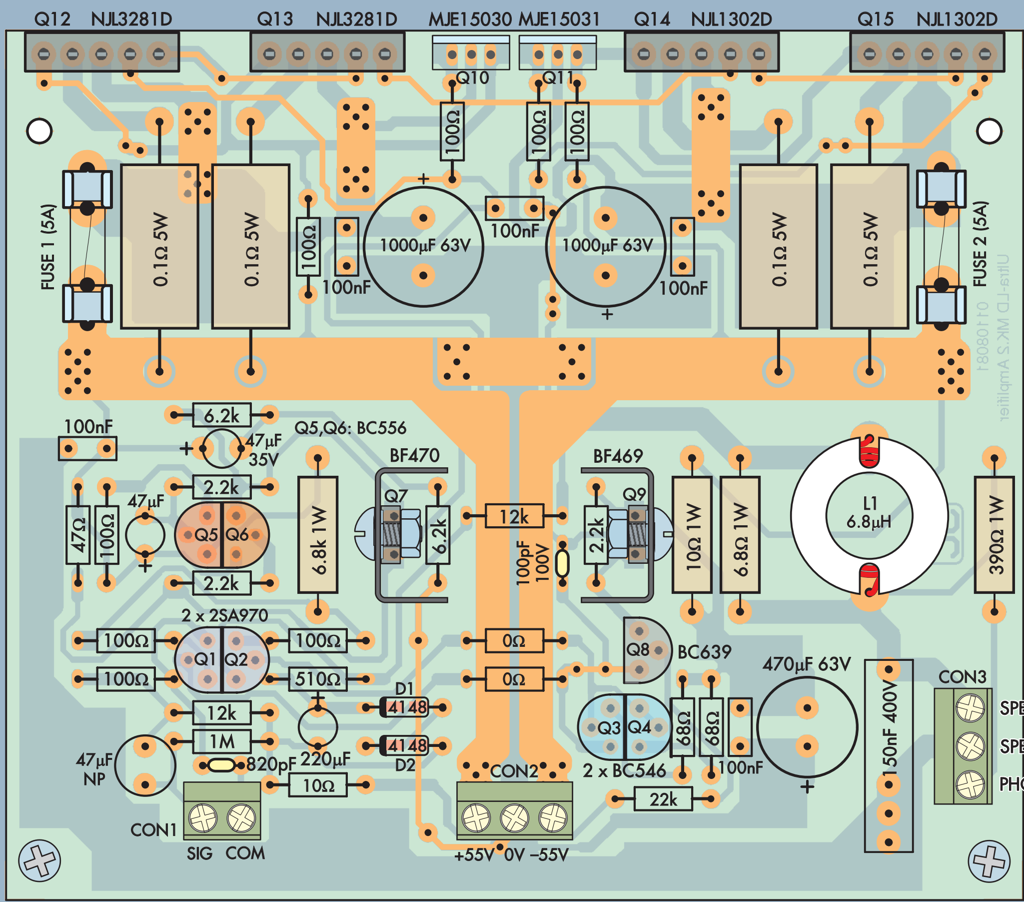


Fig.3: the PC board parts layout of the new amplifier module. The double-sided design allows much better cancellation of magnetic fields due to the asymmetric currents in the output stage.

supply voltage and signal conditions, but it will always come back to the initial 'no-signal' value. On Semiconductor also claim that the harmonic distortion of the amplifier is lower than it would be with a Vbe multiplier stage.

Fig.2 shows the method of setting the output quiescent current. As depicted here, the four integrated diodes compensate for the four base-emitter junctions that control the quiescent current in the output stage. These are the two base-emitter junctions in the driver stages (Q10 and Q11) and the two paralleled base-emitter junctions of the four output transistors (Q12, Q13 and Q14, Q15).

The quiescent current is set by the difference in voltage drops between the aforementioned base-emitter junctions and the four diodes, and this voltage difference appears across the 0.1Ω emitter resistors of the output. Typically, the voltage across the emitter resistors will be around 7-10mV, giving a quiescent current of around 70-100mA for each transistor; somewhat higher than we would have set with a Vbe multiplier.

Output RLC filter

The remaining circuit feature to be discussed is the output RLC filter, comprising a 6.8µH air-cored choke, a 6.8Ω resistor and a 150nF capacitor. This output filter was originally produced by Neville Thiele, and is still the most effective output filter for isolating the amplifier from any large capacitive reactances in the load, thereby ensuring unconditional stability. It also helps attenuate any RF signals picked up by the loudspeaker leads and stops them being fed back to the early stages of the amplifier where they could cause RF breakthrough.

Note that if the amplifier is intended for an application that requires continuous high-power output at frequencies of 10kHz or more, then the 6.8Ω resistor will need to be a 5W or 10W wirewound resistor.

Fuse protection

The output stages are fed via 5A fuses from the ±55V rails. These provide the only protection to the amplifier against short-circuits or other failures which could cause high current drain. **Note that we recommend the use of a loudspeaker protector such as the one described in the Dec '08 issue of *EPE*.**

Double-sided PC board

As already noted, a double-sided PC board is used to simplify the power supply wiring. The general layout of the PC board has two important features.

First, it has 'star earthing', whereby all earth (0V) currents come back to a central point on the board, thereby avoiding the possibility of output, supply and filter bypass currents flowing in the sensitive signal earth return conductors.

More importantly, the placement of heavy copper supply and earth tracks

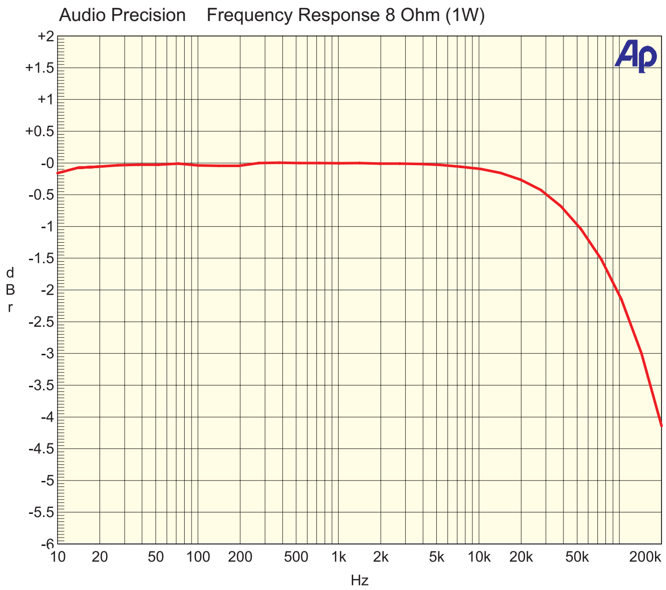


Fig.4: frequency response at 1W into 8Ω. While the minimum frequency shown here is 10Hz, the response extends well below that to around –3dB at 4Hz.

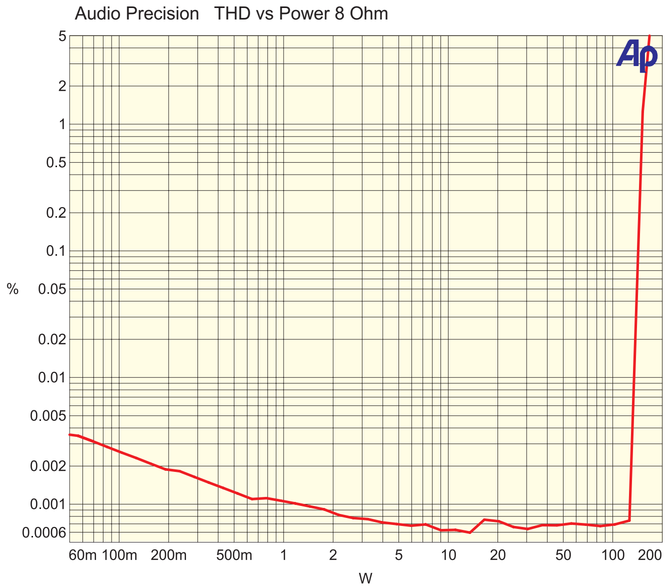
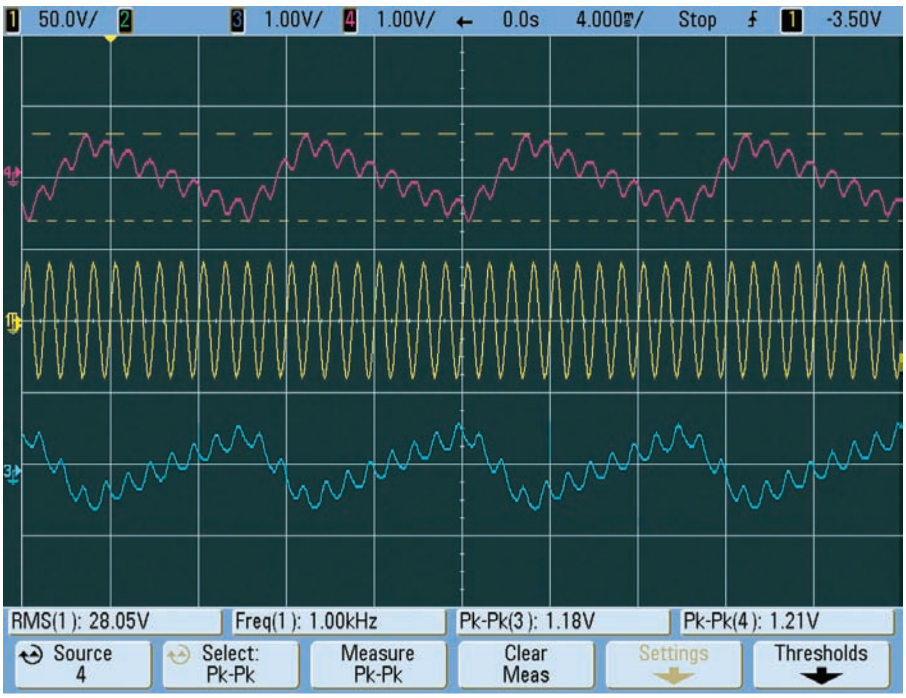


Fig.5: total harmonic distortion versus power at 1kHz into to an 8Ω resistive load. Maximum power at the point of clipping is 135W.

on the board is arranged to cancel the magnetic fields produced by the asymmetric currents drawn by each half of the output stage. In the aforementioned amplifiers, we arranged this cancellation by having the main supply leads to the module lie closely underneath the respective tracks on the PC board. While this arrangement works well, if it is to be effective it depends on the constructor following the wiring diagram very closely.

The PC board layout is shown in Fig.3.



This scope grab gives a graphic demonstration of the signal rectification phenomenon in the Class-B output stage. The centre (yellow) trace shows a 1kHz sinewave output signal from the amplifier at 100W into an 8Ω load. The top (red) trace shows the ripple on the positive supply. Note the large 100Hz sawtooth component which is ripple from the power supply. Superimposed on this is the half-wave rectified signal frequency at 1kHz. The bottom (blue) trace shows the same process on the negative supply rail.

To visualise how the field cancellation occurs, consider how the positive rail fuse (Fuse1) is placed close and parallel to the emitter resistors for Q12 and Q13. So the magnetic field produced by the half-wave currents in Fuse1 are more or less cancelled by the same current flowing back through the emitter resistors. The same mechanism applies with Fuse2 in the negative rail and the emitter resistors for Q14 and Q15.

Now consider the two heavy tracks which carry the positive and negative supply rails from the connector CON2 up the centre of the PC board and then diverge at rightangles to the two fuses, Fuse1 and Fuse2. Directly under the diverging supply tracks are the tracks which connect the pairs of emitter resistors together to connect them to the output via the RLC filter. Almost complete magnetic field cancellation takes place because of this track arrangement.

Finally, the main earth (0V) return track to CON2, underneath the board, cancels the magnetic field produced by the main supply tracks running on the top centre of the board.

By the way, merely twisting the positive and negative supply wires of a class-B amplifier together gives no magnetic field cancellation at all in the absence of the return earth. Why? Simply because the positive half-wave currents do not occur at the same time as the negative half-wave currents.

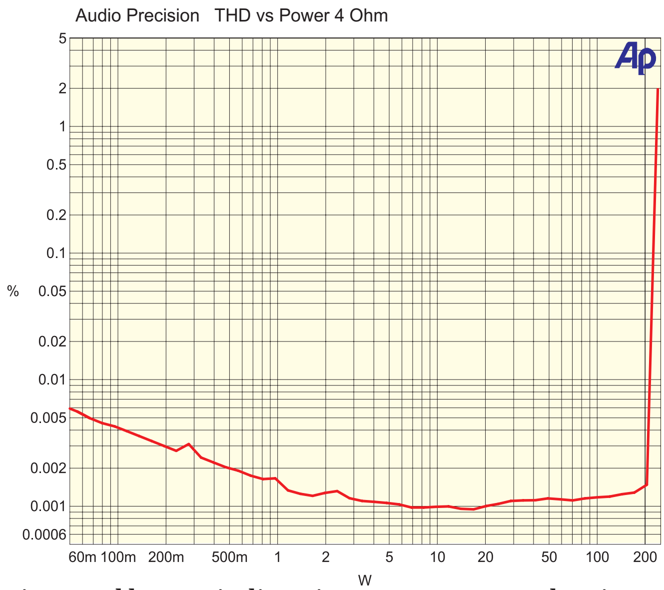


Fig.6: total harmonic distortion versus power at 1kHz into a 4Ω resistive load. Maximum power at the point of clipping is 200W.

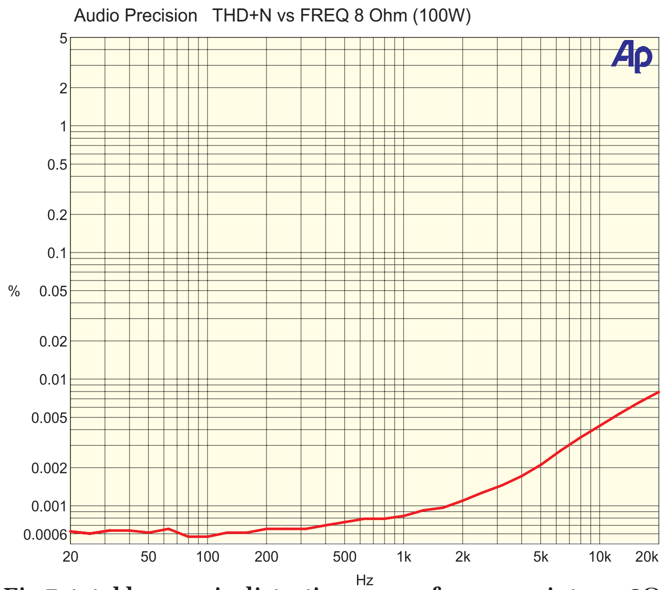


Fig.7: total harmonic distortion versus frequency into an 8Ω resistive load. This is measured with a bandwidth of 10Hz to 80kHz.

To sum up, the Class-B magnetic field cancellation technique employed is important because it greatly reduces the overall harmonic distortion of the amplifier. In this design, with a double-sided PC board complementing the new very linear ThermalTrak power transistors and special filtering of the supply rails, the results are excellent.

Finally, we need to clear up a few points. At various times we have referred to this amplifier as operating in class-B and in class-AB. Strictly speaking, the amplifier operates in class-AB, ie, a mixture of class-A, which means that a constant current flows in the output stage, and class-B which refers to the separate operation of the positive and negative sections of the output stage.

Coming next month

Next month, we will describe the assembly of the module and give the test procedure. We'll also describe a suitable power supply.

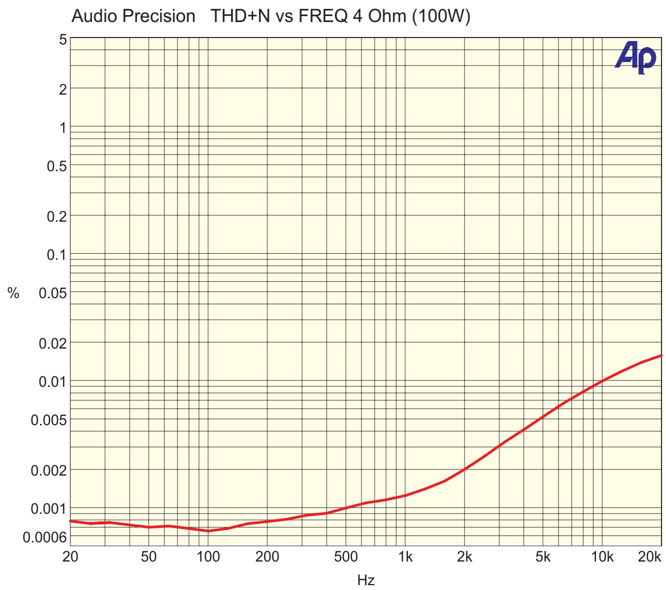


Fig.8: total harmonic distortion versus frequency at 100W into a 4Ω resistive load, measured with a bandwidth of 10Hz to 80kHz.

DSP Musicolour: adding a remote control

Part 4: By Mauro Grassi

With a small and low-cost add-on PC board, the DSP Musicolour can be operated via an infrared remote control – very handy if you want to use it in hard-to-reach places.

REMOTE CONTROL adds so much more convenience! After completing the *DSP Musicolour* design (as published in the May, June and July issues) we looked at the possibility of adding infrared remote control.

It turned out to be really simple – so here we describe how to build a simple remote control receiver PC board to allow the DSP Musicolour to be operated via a remote control that uses RC5 codes – the vast majority – or a universal remote control. The DSP Musicolour firmware contains the decoding functions.

The circuit schematic for the remote control receiver board is shown in Fig.1 overleaf. It contains little more than an infrared receiver module that amplifies and demodulates the remote control signal. The signal is then decoded by the firmware.

Finally, there is a 330Ω resistor. As the RF6 pin of the microcontroller (IC1) can function as an output as well as input, this resistor is used on the output of the module to limit the current into the data output of the infrared receiver module.

MUSICOLOUR – THE MOVIE!

It's quite hard to put into words just how sensational the DSP Musicolour lightshow really is . . . so you'll be able to see it! Around the time this issue appears, we hope to have ready a short demonstration movie which can be accessed via the *EPE* website.

Construction

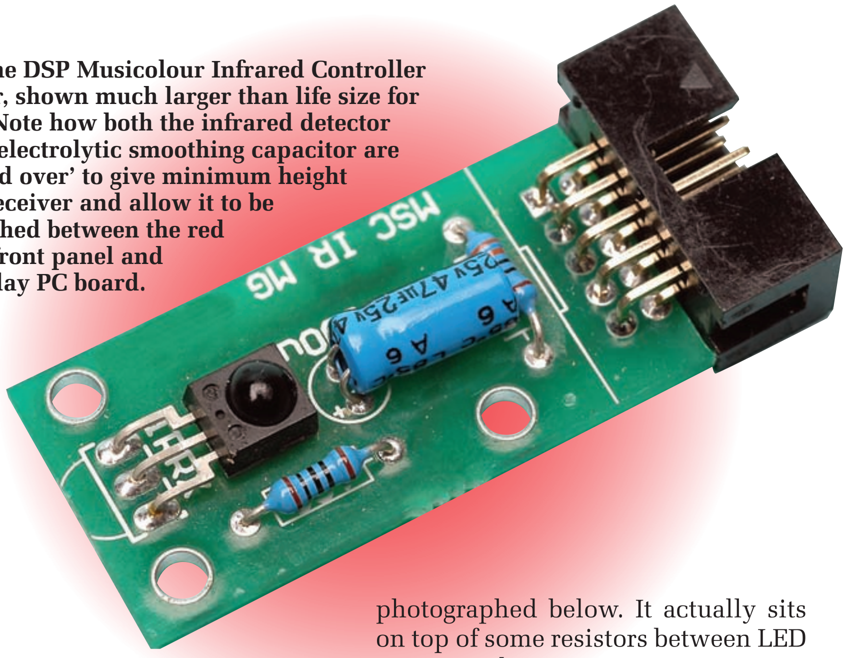
The Remote Control Receiver is built on a small (24mm × 44mm) printed circuit board. The topside component layout is shown in Fig.2. This board is available from the *EPE PCB Service*, code 764.

This is a simple board that should take a matter of minutes to build. Just refer to the component overlay and the accompanying photograph.

Begin construction by installing the resistors. There are only two of them, so it's going to be particularly difficult to mix them up. (Hint: the 100Ω has bands which start with brown and black, while the 330Ω has two orange bands!) But if in doubt, check them with a DMM.

Next is the 47µF capacitor, which, being polarised, must be oriented correctly, as shown in the component overlay. To make the PC board as low in height as possible, it must be 'laid over' 90° so that it lies along the board. Therefore you will need to bend both leads down 90° before soldering it in.

Next, solder in the infrared receiver module, allowing around 7mm of lead. Just like the electrolytic capacitor, it mounts so that it lies flush with (ie, parallel with) the PC board surface, as shown in the enlarged photo on the right. The last thing to solder in is the 10-way IDC header.



Here's the DSP Musicolour Infrared Controller Receiver, shown much larger than life size for clarity. Note how both the infrared detector and the electrolytic smoothing capacitor are both 'laid over' to give minimum height to the Receiver and allow it to be sandwiched between the red acrylic front panel and the display PC board.

Main board connection

The remote control board connects to the main board via a 10-way ribbon cable, from CON1 on the remote control board to CON3 on the main board. We explained how to make a 26-way ribbon cable connecting the main board to the display board in the June 2010 issue (page 34, under Ribbon Cable Assembly).

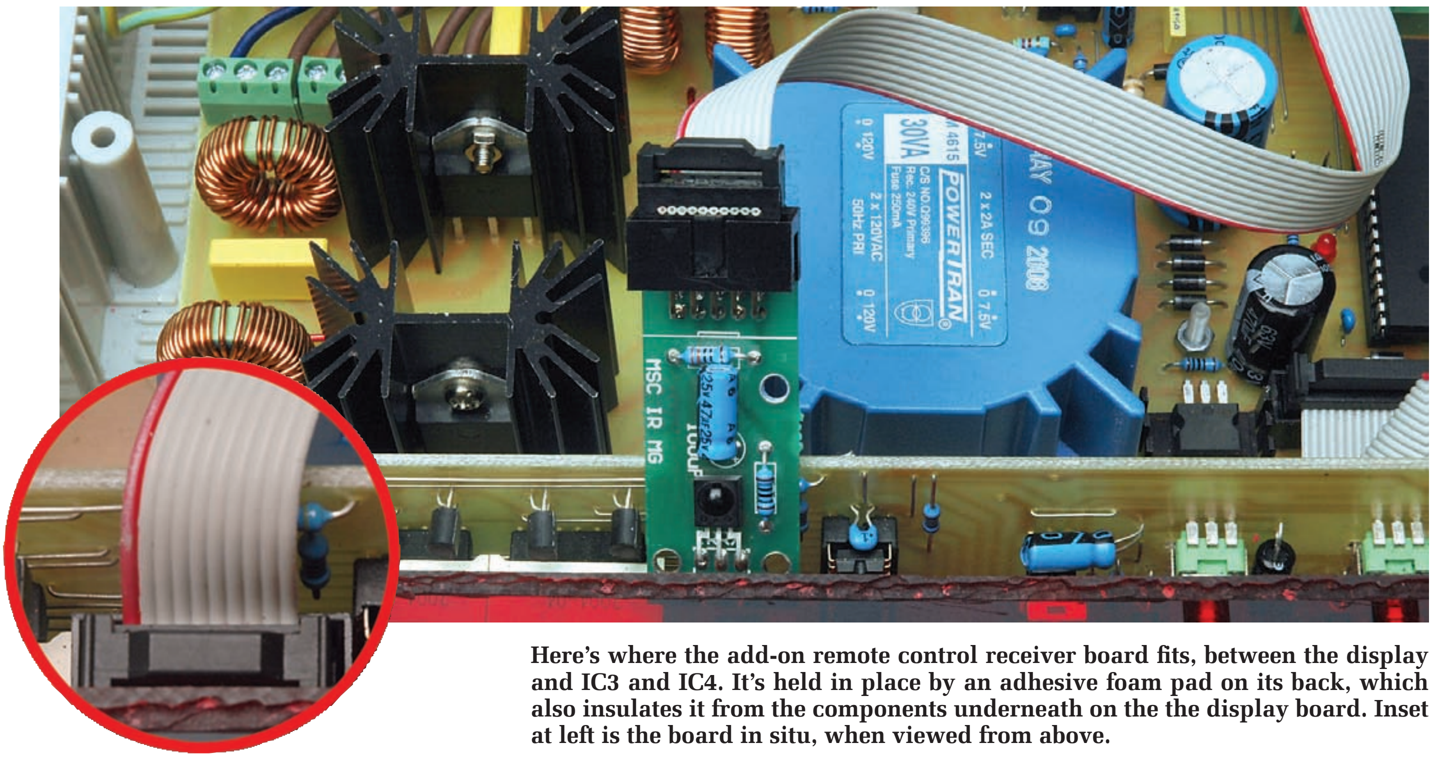
The 10-way ribbon cable used to connect the remote control board is made in the same way.

The completed remote control PC board sits between the red acrylic front panel and the display board, as photographed below. It actually sits on top of some resistors between LED array 3 and two 74HC595 ICs.

It is secured in place with a self-adhesive foam pad or two (available at any newsagent or stationer). Being a couple of millimetres thick, these pads have the added advantage of providing insulation between the remote control board and the components on the display board underneath.

You will need to open the case to install it, so you MUST first make absolutely certain that the IEC mains power lead is NOT plugged in.

The ribbon cable connecting to the remote control PC board also helps locate the board – when its IDC



Here's where the add-on remote control receiver board fits, between the display and IC3 and IC4. It's held in place by an adhesive foam pad on its back, which also insulates it from the components underneath on the the display board. Inset at left is the board in situ, when viewed from above.

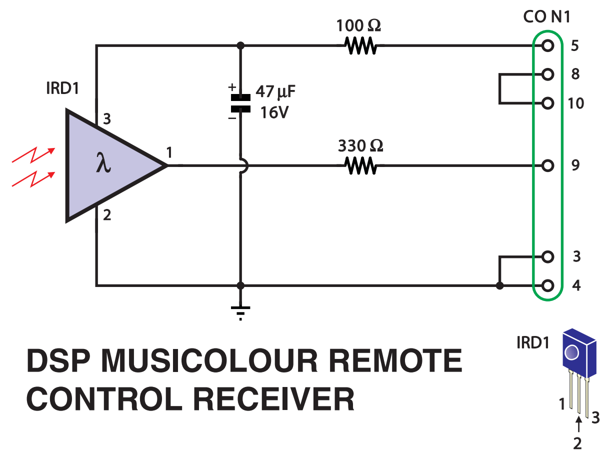


Fig.1. If you can find a simpler circuit, good luck! The Infrared Detector both receives and decodes the signal from the Remote Control. The microcontroller in the DSP Musicolour does all the hard work!

connector is plugged in, the top edges of both the controller PC board and the display board are in alignment, with just enough room for the IDC cable to go over the top of the display board and wedge between the display board and case top.

Once the board is connected, close the case and insert the screws that hold the two halves together, then (*and only then*) power up the DSP Musicolour. Don't be tempted to take a short cut and leave the screws out!

Defining the codes

There are only nine remote control codes used to control the DSP Musicolour. These must be defined at least once, using the front panel buttons, before operating the DSP Musicolour with a remote control.

First, you must make sure that your remote control is an RC5-compliant remote control. RC5 is a protocol designed by Philips, but not all remote controls in use today actually work with this protocol. Other protocols will not work with this decoder, so you should make sure that you have an RC5 remote control. If you are using a universal remote, there is a good chance of it working if you set it to a Philips appliance (eg, a TV set or VCR).

Go to SYSTEM>Remote Control and follow the prompts. You will be asked to define each of the nine keys in turn, keys 1 to 7 correspond to the buttons on the front panel in the following order: UP, SET, DOWN, CH1, CH2, CH3 and CH4.

The corresponding button LED will light and you should press the key on your remote control that you want to use to emulate that key on the front panel. Naturally, you would use the channel up and channel down buttons for up and down – it makes it easier to remember.

After the seven buttons on the front panel, the next two buttons are used to emulate the SELECT potentiometer and require you to enter a key for '+' and '–' to emulate the analogue potentiometer.

Again, you would normally define these two buttons as Volume UP and Volume DOWN on your remote control. Even universal (programmable) remote controls normally have channel up/down and volume up/down labelled.

To test that the DSP Musicolour is correctly understanding the remote control signal, you can go to the SYSTEM>RC5 Echo submenu. This will display (in hexadecimal) the 12-bit code received by the Musicolour. You should see the numbers displayed as you send commands to the Musicolour using your remote control.

We have tested the DSP Musicolour with the Digitech AR-1725 (Jaycar AR-1725) universal remote shown earlier, and we set it up as follows (most other universal remotes will work too).

Parts List – Remote Control for DSP Musicolour

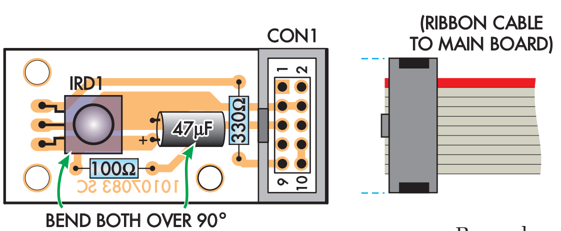
1 PC board, code 764, available from the *EPE PCB Service,* size 24mm × 44mm
1 infrared remote control using RC5 code, at least nine buttons (see text)

Semiconductors
1 infrared receiver module (IRD1) (Jaycar ZD1952)

Miscellaneous
1 10-way right-angled IDC header
1 10-way ribbon cable, approx 20cm long
2 10-way IDC cable line sockets
2 self-adhesive foam pads (adhesive both sides)

Capacitors
1 47µF 16V electrolytic, PC board mounting

Resistors (0.25W, 1% metal film)
1 330Ω 1 100Ω



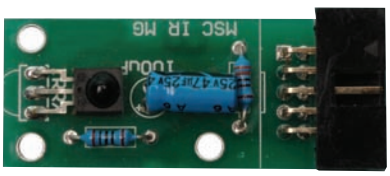


Fig.2. Here the Infrared Receiver PC board and component overlay *are* shown life size; there's not much to it! Watch the polarity on the 47µF electrolytic capacitor and note which way around the pins go on the infrared detector (actually, if you get this back to front, the lens will face down into the PC board – a pretty good indication that it's not quite right!).

Here's the display for programming your remote control – as each LED lights, you press the appropriate button on your remote control.

Button on front panel to emulate	Press this key on remote control when prompted
AUTO/UP	'Volume UP' button
SET/OK	'OK' button
USER/DOWN	'Volume DOWN' button
CH1/A	'1' button
CH2/B	'2' button
CH3/C	'3' button
CH4/D	'4' button
Potentiometer + control*	'Channel UP' button
Potentiometer – control*	'Channel DOWN' button

Table 1: this shows a suggested remote control code definition sequence using a Digitech AR-1725 universal remote control (or any RC5 remote control with 9 buttons or more) and the optional remote control decoder PC board. *Note (*): this control is not a button on the front panel, but is used to emulate the SELECT potentiometer on the front panel using the remote control.*

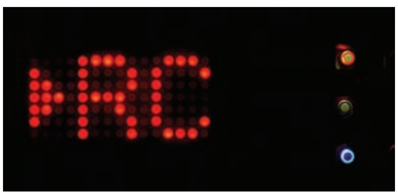
However, if your household is typical, you probably have a growing collection of once-used infrared remote controls. One of these may be suitable if it uses the Philips (RC5) protocol. If you don't know and can find the code sheet for it, program it for any Philips device and try it out. You can't do any harm, even if it is wrong. It simply won't work!

Of course, it may be that the batteries are flat . . . If it doesn't have a tell-tale visible LED, then the easiest way to check that an infrared remote control is actually outputting infrared is to view it through just about any digital or video camera. Most are sensitive to infrared and you should see bright white (or sometimes green) flashes in the viewfinder when aimed at the remote control.

If you are using the Digitech remote control, set it for the VCR 115 code (this is the code for a Philips VCR, although many other Philips codes should work too).

Go to the SYSTEM>Remote Control submenu. There you will see whether the remote control has been defined. If it indicates that it has not been defined, you may press SET to define the remote control codes. You will be asked for confirmation, and if you proceed, you will be able to define the remote control codes to suit your remote. You'll be prompted to define each of the nine keys in turn. You can refer to Table 1, which provides a suggested definition (you can of course choose another sequence of keys to define if you wish).

Once you've defined the remote control codes, the DSP Musicolour will respond to both the buttons on the front panel and to the remote control keys you have defined. So you can operate the DSP Musicolour with either. ***EPE***



This screen is for checking the remote control: it displays the received codes from your remote control, as decoded by the firmware.

Recycle It!

BY JULIAN EDGAR

Electronic Watches

THESE days, electronic watches are dirt cheap. I mean, you can buy a watch that has features and accuracy that would once have cost hundreds of pounds – and it might now cost only £10!

That's one way of looking at it, but when you actually go shopping for a watch it's amazing how many watches are ugly, or huge, or have intrusive and complicated features that you simply don't want. And those watches of stylish simplicity from well-known manufacturers? Well, in some cases they're still hundreds of pounds!

But to get a really good watch, all you have to do is find one that's been discarded because of its flat battery – and then replace the battery.

In the past, do-it-yourself battery replacement has often been very difficult – to unscrew the back you needed special tools and holders available only at high cost from specialists. In short, replacing watch batteries yourself simply wasn't worth it. But now, if you buy on eBay direct from Hong Kong, you can have a full watch back removal tool (adjustable, and with differently shaped 'bits'), delivered to your UK home for a total of £5.61!

With do-it-yourself battery replacement now so cheap, it's worth digging out your old flat-battery watches – sometimes cherished favourites – and also keeping an eye out for discarded high quality watches.

Watch back removal tool

This story came about when my five year old son picked up a watch while we were dropping off some rubbish at the local rubbish tip. To be honest, I was indifferent to his acquisition – if he wanted to, he could take home the watch, give it a wash and then wear it on his wrist as a 'play watch'. But when we got home, and we'd washed it, I looked at it more closely.

And the watch actually looked rather good! A waterproof sports analogue design, it had a seconds hand (something I like), large glow-in-the-dark minute and hour hands and large numbers. In fact, it looked a perfect watch to take camping or cycling. And, apart from the fact that it had stopped, it was also in excellent condition.

I turned the watch over to find the common difficulty – a screw-on back with six small indents into which a special tool fits. I tried using two small screwdrivers to rotate the back,

Replacing the battery in most watches is difficult because the screw-on back requires a special tool that fits into the peripheral indents

However, this watch back removal tool is now available so cheaply that it's worthwhile replacing batteries in watches that have been discarded because they have stopped working. The tool is adjustable for a wide range of different watches

Using the special tool, it took only moments to open the back and remove the battery... which was as flat as the proverbial pancake! Without the tool, getting the back off without damaging the watch (or your hands) is difficult

Rat It Before You Chuck It!

Whenever you throw away an old TV (or VCR or washing machine or dishwasher or printer) do you always think that surely there must be some good salvageable components inside? Well, this column is for you! (And it's also for people without a lot of dough.) Each month we'll use bits and pieces sourced from discards, sometimes in mini-projects and other times as an ideas smorgasbord.

And you can contribute as well. If you have a use for specific parts which can easily be salvaged from goods commonly being thrown away, we'd love to hear from you. Perhaps you use the pressure switch from a washing machine to control a pump. Or maybe you have a use for the high-quality bearings from VCR heads. Or perhaps you've found how the guts of a cassette player can be easily turned into a metal detector. (Well, we made the last one up, but you get the idea . . .)

So, if you have some practical ideas, do write in and tell us!

but this didn't work – and slipping with the screwdrivers can give you a nasty injury. One of the problems with unscrewing watch backs is that they're typically tightened down onto an O-ring, and this tends to hold the back firmly in place until you develop quite a lot of unscrewing torque.

It was then I turned to eBay to find the 'watch case opener tool boxset wrench remover screw back' being sold at a buy it now price by 'Great-Digital'. (Similar tools are also available from other vendors.) As stated, purchase and delivery cost to the UK is, at the time of writing, £5.61.

So what do you get? In a hard case, you receive a tool that has three prongs, adjustable for spacing. You also get six sets of different 'bits', the different shapes designed for the various recesses to be found on watch backs. I doubt if the tool would stand up to daily use in a shop specialising in replacing watch batteries, but for the home user it's perfect.

To use the tool, you select the correctly shaped bits and set the spacing so that the three tool-bits fully engage with appropriate watch recesses. You then place the tool so that its prongs are facing upwards, nestle the watch into position, and then while holding the tool stationary, push the watch down on the prongs and rotate it anticlockwise, so unscrewing the back. (Note: it's far easier to hold the tool and rotate the watch than to try holding the watch and rotating the tool!)

Scratched Glass?

If the glass lens of the salvaged watch is lightly scratched, it's worth seeing if the scratches can be polished out. Easiest and cheapest is to use a moistened soft cloth with toothpaste as the abrasive. When polishing the glass use soft pressure and a circular motion.

Replacing the back is a reversal of the above procedure – you may want to smear a microscopic amount of lubricant (eg, petroleum jelly) on the O-ring before replacing the back.

Battery replacement

Battery replacement is normally straightforward – it often requires the use of a very small Philips head screwdriver to undo a retaining screw or in some cases, the battery will come out if a small spring strap is lifted. Before removing the battery, ensure that you take note of the polarity with which it has been inserted!

Rather like the watch back removal tool, if you know where to look, batteries are available extremely cheaply – you can also easily and at low cost buy a card with a range of cells of different sizes and voltages.

With a new battery inserted (the battery cost less than £1), the watch was as good as new. I wear it when cycling and camping – it's ideal for those activities where damage is more likely

Conclusion

And the watch my son picked up for nothing? A new battery in it and it started working again. Now all I have to do is to work out how his 'play watch' can become my 'camping watch'!

PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

A Propeller-based Internet computer – Part 1

IN our previous two episodes of *Pic n' Mix,* we took an introductory look at the Propeller processor from Parallax, and saw how ideal it is for solving some of the problems that are so difficult to handle on a PIC. We also looked at a powerful low-cost development system from Nurve networks, which could easily fulfill the computing requirements of many an interesting project.

There is, however, no substitute for building your own circuit to understanding how a processor works. And besides, it's more satisfying and fun doing it this way (unless you have an urgent deadline and just want some hardware that works – in which case, we would recommend a development board from Nurve, Parallax or Spinvent). So, over the next few months we will develop our own circuit, hopefully having a bit of fun along the way.

So what kind of circuit will we build? There are a number of free circuit designs available for the Parallax processor, all of them excellent in their own right. Many circuits are designed specifically for running old style video games, and are excellent fun if you want to recreate the 1980s video arcade feeling. As there are so many of these designs available, we thought we would focus on something a little different, and perhaps a bit more ambitious.

Internet computer

What we have in mind is a computing platform capable of displaying colour text at high resolution, have a standard keyboard and mouse interface, stereo sound output, an Ethernet interface and SD-Media socket for local data storage. The device should be capable of supporting email, instant messaging, twitter and other simple text-based Internet protocols.

The idea comes from the author's experience of using a computer at home. For the majority of the time the PC is left switched on waiting for email or instant messages to come in. Given a typical PC draws several hundred watts, that's a lot of wasted energy and cost. A PIC and Propeller-based system should be able to do the same (albeit in text only) with less than a couple of watts in power consumption, so if we can achieve this ideal, then it will save money *and* be environmentally friendly.

We are going to develop this over the coming months, building up the functionality as we go along. The circuits presented will change each month, so you may want to wait until the final circuit design before building this yourself, or experiment with the design on a solderless breadboard. Out of personal preference, we create circuits on matrix boards – partly because this makes the circuit look 'prettier', but also because it makes it easy to transport (many a *Pic n' Mix* article has been written in a hotel room or airport!).

Choose whatever approach suits you. The circuits are low power and relatively low frequency, and therefore suit any construction technique. At the end of the series, should there be enough interest, we will produce a PCB design and construction article to produce a more polished end result. Each article will present a complete and useful circuit, however, so you don't have to wait until the final article to take advantage of the Propeller processor.

Design approach

The aim (as the final design has not yet been fully worked out yet) is to use the Propeller

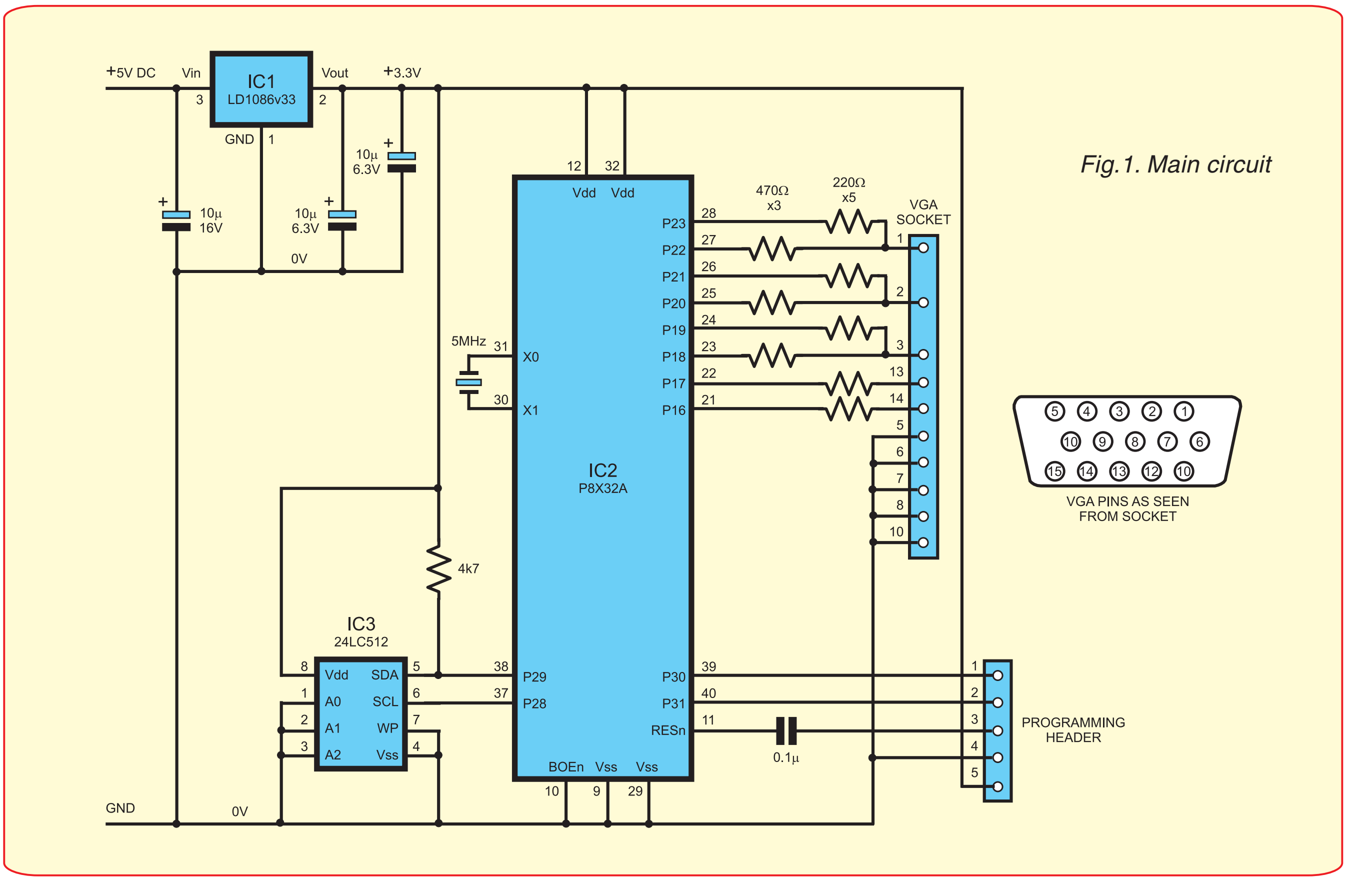


Fig.1. Main circuit

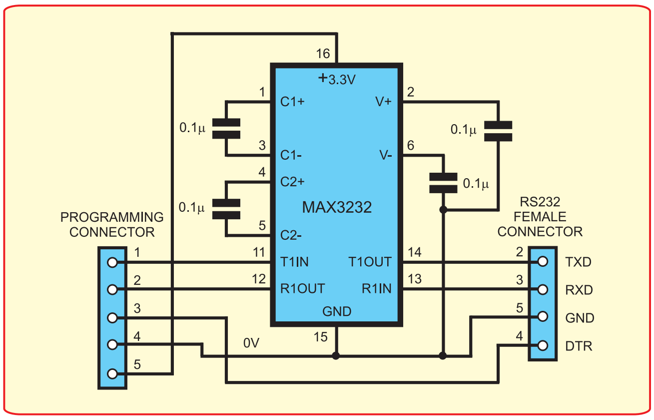


Fig.2. Programming interface

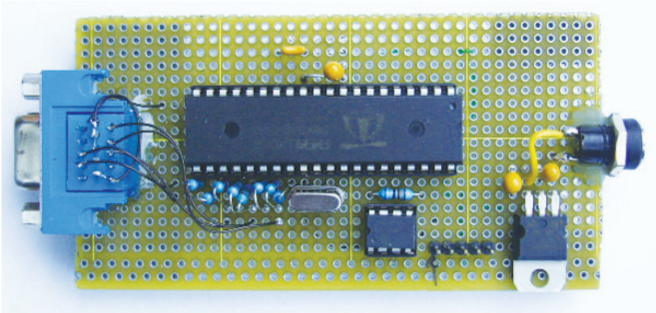


Fig.3. The completed board

processor as a video, keyboard and mouse interface, with a PIC24 processor providing the Ethernet interface and main computing functions. The PIC24 will be connected to an ENC28J60 Ethernet interface IC (a part already discussed in *Pic n' Mix*). The PIC24 has a much larger program memory capacity than the Propeller, and also a very rich set of peripheral hardware functions, so the two processors compliment each other well.

The processors will communicate with each other through a high speed RS232 interface (or possibly an SPI bus, depending on the demands of the link). These three ICs have been chosen because they are easily available through the usual component suppliers. More importantly, they come in DIL packages, making the design very easy to construct.

A huge range of free software is available for both processors, and our design approach will make full use of these. Video generation, SD Media card support, keyboard, Ethernet and Internet protocol software are examples of what we will be re-using from the libraries provided by the chip manufacturers. At times, it will appear that the complexity of our software development is the actual gluing together of other people's code rather than inventing from scratch – in true engineering fashion!

We will start this month with the most impressive and yet simplest piece of functionality – colour video generation. This also gives us the chance to experiment with the software tools and programming interface, before moving on to more interactive functionality. This circuit is still useful in it's own right, and can form the basis of your own designs. It is also very cheap, costing no more than £10.

Initial circuit

The initial circuit design is shown in Fig. 1. On the surface, it looks like a typical microcontroller circuit, but as this is a new processor for *Pic n' Mix* let's go through the circuit in some detail.

The Propeller (or P8X32A to give it it's formal title) requires a fixed 3.3V supply at up to 100mA when run at 100MHz. This is supplied by our now standard 5V to 3.3V power supply circuit, consisting of IC1 and two 10μF capacitors. The circuit is quite tolerant to minor changes in capacitor values, but be careful to use capacitors rated at a voltage at least 20% above what they will be working at.

The supply current of 100mA may come as a surprise, but don't forget this is not just a single processor – it is a collection of eight independent processors, each running at up to 100MHz. What *would* we have made of that kind of processing power 25 years ago!

The oscillation source is derived from a standard 5MHz crystal. A nice touch is that no capacitors are required, saving on board space (plus, there is never a 22pF capacitor in stock when you need one!). No pull-up is required on the reset pin (RESn), saving a resistor.

Connection to a VGA socket is very simple. For each of the primary colours – red, green and blue – a two-bit digital-to-analogue converter is formed using two resistors. This provides six bits for each pixel, or 64 colour combinations. A further two resistors are required to drive the vertical and horizontal sync signals. Reasonable precision resistors (1%) are advisable here, but not essential.

An EEPROM completes the main circuitry, and its presence is required for standalone operation. The Propeller processor has no on-chip non-volatile program memory storage, so programs are either downloaded on power-up through the serial port or stored in off-chip EEPROM and loaded automatically on power-up. Once the program data has been transferred from EEPROM, the serial interface pins on the processor become general purpose I/O. Hence the use of a 64KB EEPROM device – we can use the extra 32KB of non-volatile storage for our own use, if we so choose. The use of an external non-volatile code storage device is an unusual feature, but one that gives great flexibility, and no doubt helps reduce the cost of the processor.

Programming interface

Although the processor has no on-chip programmable memory, it does support a programming interface to allow data to be transferred across to the EEPROM. This is implemented as a simple serial interface, and the support wiring for this is shown in the lower right of Fig. 1. We have used a simple five-pin 0.1inch pitch SIL header strip for the physical interface itself.

The Parallax programming utility software assumes an RS232 interface is used for programming the EEPROM, so we have put together a very simple interface, as shown in Fig. 2. This ciruit was constructed on a small matrix board with flying leads, and then covered in glue (epoxy or hot-melt) to give it some physical stability – programming interfaces lead a hard life in our lab!

RS232 ports are becoming a rarity on computers today. However, with cheap USB to RS232 leads readily available this should not pose a problem. The programming interface is very simple and also very reliable, and neither construction nor use should pose any problems.

After power-up, the programming pins P30 and P31 return to normal I/O pins, which means the same programming interface can double as an RS232 interface – a wonderful feature, saving the creation of another circuit and wiring to a separate header. We love it!

The photo shows the main circuit built up on a matrix board. Although the VGA sockets can be purchased through the usual electronics suppliers, we have taken a leaf out of Julian Edgar's book and recycled a socket from an old PC. The pins on the socket will be labelled as per the picture in Fig. 1, but you may need to 'buzz' the pins to confirm which is which. With so few wires to connect, the board was completed in a few hours.

Two-part epoxy resin was used to fix the VGA and power sockets to the matrix board before soldering. The result is a very solid construction that has survived many trips in a briefcase on a bike to and from work.

The Propeller processor is available from the usual electronics retailers, although we found that Spinvent (**www.spinvent.co.uk**) are by far the cheapest source in the UK.

Next month, we take a look at the tools for programming the board, and how we can use some of the freely available software to bring it to life.

Circuit Surgery

Regular Clinic

By Ian Bell

A potential divider

ECHOING last month's power supply theme, we have a question from *EPE Chat Zone* (**www.chatzones.co.uk**) user **jameselstone**. His question is about voltages dividers and relates to the regulator circuit shown in Fig.1.

If I have a voltage regulator achieving a Vout of 3.6V for driving a pair of LEDs, can I use a resistor based voltage divider to get down to 3V?

The 3V is to run a PIC18F series, an LCD and a few other odd, but low power components...

What are the pro and cons of this? Any advice? (See Fig.1)

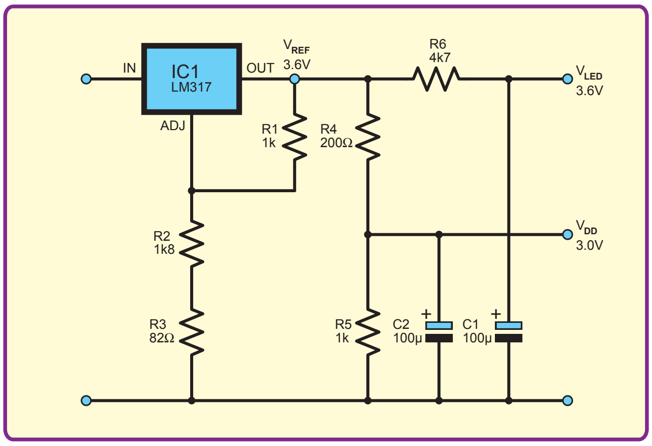


Fig.1. Circuit referred to by jameselstone in his Chat Zone question.

Soon after jameselstone's post there was another question about potential dividers from *Chat Zone* user **8Bit**

I'm a little confused about these, as surely you can create the same potential by using just ONE resistor of the combined value of the two used in the 'divider'?

Back to basics

So this month we will be going 'back to basics' and looking at the potential divider (voltage divider) and the circuit theory which helps us analyse its behaviour. A potential divider circuit on its own is shown in Fig.2.

As usual, other *Chat Zone* users asked for more details about jameselstone's circuit and application. We will not look at all the details of the power supply problem here, for example concerning the 3.6V LED supply, or exactly what voltage the PIC should run on. We will, however, note that the 3.0V supply voltage needs an accuracy of around ±5%, and that current demand might be from 500mA to 650mA.

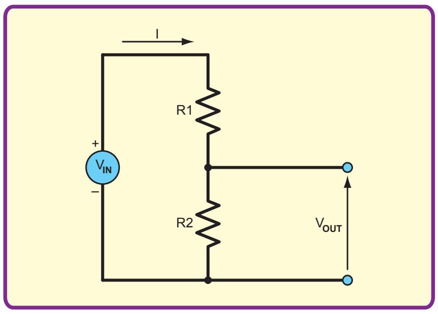


Fig.2. Potential divider

Jameselstone rejected the idea of using a potential divider in a later post in the *Chat Zone* thread, and we will soon see he was right to do so. Many experienced readers will, of course, immediately know that it is not a very good idea; however it is worth looking at potential divider circuits in more detail and this example is useful as a starting point for such a discussion.

Both jameselstone's and 8Bit's questions are about obtaining a desired voltage from a larger voltage source just using resistors. To find out if a potential divider is a suitable approach to this in a given situation we have to ask:

- How much power will be dissipated in the potential divider?
- How accurately can we set the output voltage with no load?
- How much will the voltage change as the load varies?

To do this, we have to know the nominal load current (or resistance) and by how much we might expect it to vary.

From Fig.2, the total current in the series resistors which form the divider, using Ohm's Law, is:

$$I = \frac{V_{in}}{(R_1 + R_2)}$$

The voltage dropped across resistor R_2 is the output voltage, and is, again by Ohm's Law:

$$V_{out} = IR_2$$

Using the first equation for I, and substituting this into the equation above, we get the output voltage in terms of just the input voltage and resistor values:

$$V_{out} = \left(\frac{R_2}{R_1 + R_2}\right)V_{in}$$

This is sometimes referred to as the potential divider equation. From this equation we see that because $R_1 + R_2$ must always be larger than R_2, V_{out} is always less than V_{in} by a factor determined by the resistor values.

If we assume R_1 is n times the value of R_2, that is $R_1 = nR_2$, the potential divider equation becomes:

$$V_{out} = \left(\frac{R_2}{nR_2 + R_2}\right)V_{in}$$

We can cancel the R_2 terms to get:

$$V_{out} = \left(\frac{1}{n+1}\right)V_{in}$$

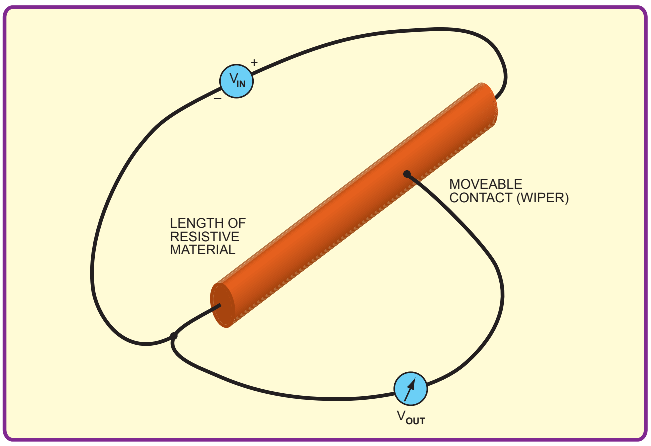


Fig.3. We can measure the voltage along a uniform piece of resistive material. This is the basis of the potentiometer

So, output voltage depends only on the relative values of the resistors, not on their absolute values. The current flowing through the divider does of course depend on the absolute resistor values, as does the power dissipation.

If both resistors are the same value (so $n = 1$) the output voltage is half the input voltage. For example, if $V_{in} = 10V$ and $R_1 = R_2 = 1k\Omega$, then $V_{out} = 5V$. Similarly, with $R_1 = R_2 = 100k\Omega$, then $V_{out} = 5V$. For $R_1 = R_2 = 1k\Omega$ the current in the divider is $10V/2k\Omega = 5mA$, but for $R_1 = R_2 = 100k\Omega$ the current in the divider is $10V/200k\Omega = 50\mu A$.

For jameselstone's circuit we have, as indicated on Fig.1:

$$V_{out} = \left(\frac{1000}{200+1000}\right) \times 3.6 = 3.0V$$

In this case, $n = 1/5$ and the output voltage is 5/6 of the input voltage. The current through the divider is $3.6V/1200\Omega = 3mA$.

8bit asks if we can use a single resistor to obtain the same voltage. If we connect a single resistor of value $R_1 + R_2$ across the same voltage V_{in} as used with our potential divider then the same current I as we calculated above will flow, and assuming the resistor has a physically and electrically uniform structure, the voltage will vary steadily from 0V at one end to V_{in} at the other end. If we connect at a point a fraction of $1/(n+1)$ of its length from the 0V end we will measure V_{out} as calculated above (for $R_1 = nR_2$). This is illustrated in Fig.3.

Potentiometer

Weather or not we can access or measure the voltage part-way along a single resistor like this will depend on how it is constructed. Most ordinary resistors for circuit use will be coated in insulating material, making it impossible to connect to them electrically along their length. However, if we had a uniform rod of resistive material we could conduct such an experiment.

A single resistor with a moveable contact (wiper) point is found in a common electronic component: the potentiometer. Potentiometers (or 'pots') are available with linear and rotary movement, and are packaged to provide a convenient means of adjusting the wiper position. Some potentiometers are designed for front-panel control and others, known as 'trimmers' are intended for one-off or infrequent set-up adjustments. Fig.4 is a schematic of a variable potential divider formed using a potentiometer. The wiper is connected to V_{out}.

The power dissipated by a resistor, R, with a voltage V across it is given by V^2/R, so the power dissipation in a two-resistor potential divider is:

$$P = \frac{V_{in}^2}{(R_1 + R_2)}$$

For jameselstone's circuit in Fig.1, the potential divider dissipates 10.8mW. If we make both resistors ten times larger ($2k\Omega$ and $10k\Omega$ in this case) V_{out} would not change because the *ratio* of the resistor values has not changed. The current flowing and the power dissipated, however, would be ten times smaller: 1.08mW.

From a power perspective therefore, we should use the largest possible resistor values, but as we shall discuss soon, the larger the resistors the stronger the effect of loading, limiting the use of very large values. We will return to this shortly.

The accuracy of the voltage we get from a potential divider, compared with what we designed it to be, will depend on the accuracy of the resistor values and V_{in}. If, for simplicity's sake, we assume V_{in} is accurately set, the accuracy of the divider will depend on the resistors.

One useful property of the potential divider is that if both the resistors are out by the same factor the voltage is still equal to the designed value. So, for example, in jameselstone's circuit, if the resistors are both 5% too large (210Ω and 1050Ω, instead of 200Ω and 1000Ω) we get an output voltage of:

$$V_{out} = \left(\frac{1050}{210+1050}\right) \times 3.6 = 3.0V$$

which is still equal to the required value. This is because the output voltage depends on the resistor ratio, not their absolute values – the same percentage error in both will not change their ratio.

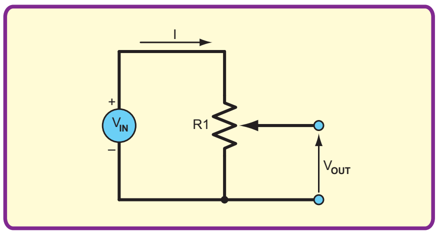


Fig.4. Schematic for a potential divider using a potentiometer

Ratio-based circuits

Ratio-based circuits are very useful in situations where components are subject to errors, but two or more components can be designed or fabricated so that the errors affect them all equally. For example, if both resistors in the potential divider have exactly the same temperature coefficient, *and* the circuit is constructed to ensure that they are likely to be at the same temperature at all times, then the output voltage would be stable with temperature, even if the resistors' values changed significantly.

Circuits with properties depending on component ratios are common in integrated circuit design because the ratio of component values (capacitance, resistance, transistor gain etc) on silicon can usually be controlled much more precisely than absolute values. A typical example would be a filter circuit whose characteristics depend on the relative values of two or more capacitors.

Unfortunately, here we are using discrete components, so we cannot assume their errors will be matched when we purchase them. If we buy two 5% resistors, one might be 5% too large and the other 5% too small. This is the worst-case scenario for a potential divider, so it is useful to see what happens with our example.

If resistor values are actually 210Ω and 950Ω, we get a voltage of:

$$V_{out} = \left(\frac{950}{210+950}\right) \times 3.6 = 2.9843V$$

This is an error of about 51.7mV, which is about 1.7%. With the other 'worst case' combination of 190Ω and 1050Ω we get an error of about 48.4mV or 1.6%. We seem to have done well here – the errors are less than the resistor tolerance, but this will not always be the case. It is possible to get errors significantly larger than this.

Consider a potential divider in which we swap round the two resistors we have been using, so that the lower one (R_2 in Fig.2) is 200Ω and the upper one (R_1) is 1000Ω. The ideal output voltage will be

$$V_{out} = \left(\frac{200}{200\ +\ 1000}\right) \times 3.6 = 0.6V$$

Now, if we repeat the calculations with one of our worst-case error examples for 5% resistors, we get:

$$V_{out} = \left(\frac{210}{210+950}\right) \times 3.6 = 0.6517V,$$

which again is an error of 51.7mV.

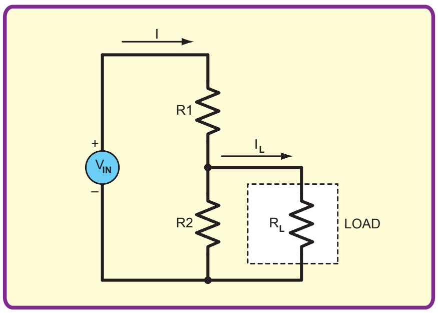


Fig.5. Loaded potential divider

However, this time we have a much smaller target voltage, so the percentage error is larger – about 8.6% – larger than the individual resistor tolerances.

On load

So far, the potential divider circuits we have discussed have been 'open circuit', that is we have not connected any other circuitry to the output. If we do, we load the potential divider and the output voltage will change to some extent. This is an important consideration when deciding if a potential divider is appropriate, or when checking if we have chosen the most appropriate resistor values. There are a number of ways of approaching this problem.

The schematic of the loaded potential divider is shown in Fig.5. If we have a known load resistance we can work out the voltage across the load by finding the parallel combination of R_2 and R_L in Fig.5. We can then use this value in the potential divider formula to calculate a revised value for V_{out}.

For two parallel resistors, R_2 and R_L, we have a combined resistance R_p given by:

$$\frac{1}{R_P} = \frac{1}{R_2} + \frac{1}{R_L}$$

So

$$R_p = \frac{R_L R_2}{(R_L + R_2)}$$

If we take our example potential divider (from Fig.1) and connect a 10kΩ load the effective value of the R_2 resistor (in Fig.2) becomes:

$$R_p = \frac{10000 \times 1000}{(10000 + 1000)} = 909.1\Omega$$

The output voltage therefore drops from 3.0V to:

$$V_{out} = \left(\frac{909.1}{200 + 909.1}\right) \times 3.6 = 2.95V$$

Performing a similar calculation for a load of 100kΩ gives 2.995V, both of which may be acceptable. However, if the load is 1kΩ, the output voltage drops to 2.57V, which is well below what is required. As a rule of thumb, a load resistance connected to a potential divider should be at least ten to one hundred times larger than the resistor across which the load is connected.

In many cases, such as jameselstone's power supply example, we do not know the exact load resistance, but we do know the range of current which has to be supplied. A useful reality check is to calculate the load current for a short circuit load, that is R_L=0Ω in Fig.5. This is simply the current through $R1$ if it is connected directly across V_{in}. In this case we have 3.6Ω/200Ω which is 18mA.

The potential divider cannot supply a current higher than this into a grounded resistive load; and at this current the voltage across the load is zero. This immediately proves that the potential divider in Fig.1 is unsuitable for the required power supply application, which requires over 500mA at 3.0V.

Calculating the short circuit output current of the potential divider is useful because it helps us find the effective *internal resistance*, or *source resistance*, of the voltage source formed by the potential divider. We also need the open circuit voltage (the unloaded potential divider output voltage), which we already know is 3.0V. From this we can find our source resistance from 3.0V/0.018A =167Ω. This is equal to the parallel combination of the two potential divider resistors.

We can then replace the potential divider with the equivalent circuit shown in Fig.6, in which the source voltage, V_S, in our case is 3.0V and the source resistance, R_S, is 167Ω. This circuit behaves exactly like the potential divider in terms of voltages and currents.

This idea is not just applicable to potential dividers; any combination of independent voltage sources, current sources and resistors, for which we can designate two output terminals, is equivalent to a single voltage source and series resistor at those terminals.

Thévenin equivalent

This is an important piece of circuit theory known as *Thévenin's theorem* – the circuit in Fig.6 is called *Thévenin equivalent circuit*. The same approach can be used with AC circuits where the sources are all of same frequency, in which case we work in terms of impedance and can include capacitors and inductors in the original network. One limitation of this approach is that the total power dissipation in the equivalent circuit is not the same as in the original.

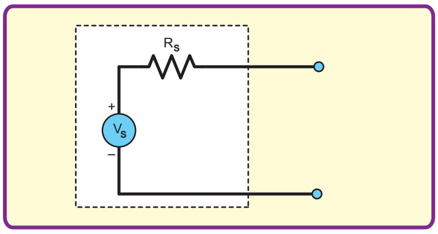


Fig.6. Equivalent circuit for the potential divider

To obtain the Thévenin equivalent for any suitable circuit we find the open circuit output voltage and then the short circuit output current. The open circuit voltage is used as the equivalent source voltage and the open circuit voltage divided by the short circuit current gives the source resistance. This and other types of equivalent circuit are used widely in circuit analysis and design, and are the underlying theory behind well-known concepts such as input and output impedance.

Fig.7 shows the Thévenin equivalent circuit of our potential divider connected to a load resistance. The load and source resistance form another potential divider, which determines the load voltage. If we look at a load of 10kΩ again, the potential divider equation for Fig.7 becomes:

$$V_{out} = \left(\frac{167}{167 + 10000}\right) \times 3.0 = 2.95V$$

which, as expected, gives us the same output voltage as we calculated above.

Use of the equivalent circuit makes it easy to calculate the variation in output voltage as load current varies. We have already seen that obtaining 500mA is impossible with this setup, so we will assume a more realistic requirement of current: from 500μA to 650μA. For I_L = 500μA, R_S will drop 500μA × 167Ω = 0.0835V, so output will be about 2.92V. At 650μA the output will be 2.89V. If we had a ±5% voltage variation requirement, this would be acceptable.

We can use the equivalent circuit to work back to a potential divider which might be able to deliver the required current in the original power supply scenario. To meet the specification, R_S must drop no more than 5% of 3V at 650mA. 5% of 3.0V is 0.15V, so the maximum value of R_S is 0.15V/650mA = 0.23Ω. Our smallest potential divider resistor will need to be around this value, so lets try R_1 = 0.2Ω and R_2 = 1Ω (remember we need a 1:5 resistor ratio for a 3.0V open circuit output).

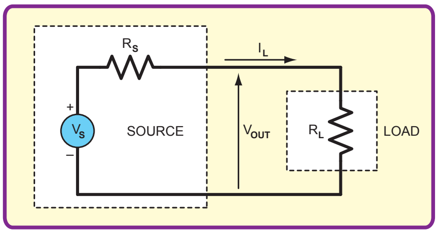


Fig.7. Equivalent circuit for the potential divider with load

With these values the short circuit load current will be 3.6V/0.2Ω = 18A, so the source resistance is 3.0V/18A = 0.167Ω. At 650mA this will drop 0.11V so the output will be 2.89V and our voltage will be within specification. Of course, this is not practical due to the current and power dissipation in the divider. With no load, the divider current is 3.6 V/1.2Ω = 3A (1.2Ω is the total resistance). The power dissipated by the divider with no load is $3.6^2/1.2$ = 10.8W – extremely wasteful!

We have shown that jameselstone's initial idea of using a potential divider to obtain a power supply voltage, as he quickly realised, is not practical. However, this has proved a useful example of applying some basic circuit analysis techniques, and as a basis for looking at the properties of potential dividers in general. There are many situations in which potential dividers are very useful, transistor biasing and volume controls using potentiometers are perhaps two of the most well known.

INTERFACE

By Robert Penfold

Microsoft's Visual BASIC 2010 Express

When this series first appeared, which must have been well back in the previous century, the software that accompanied interface circuits was written in BBC BASIC, GW BASIC, and programming languages of that ilk. While these were rather crude by current standards, as was the hardware of the time, using them to communicate with your own add-on devices was relatively straightforward.

As hardware and programming languages have progressed, some of the so-called improvements have actually been steps backward for those wishing to build their own computer add-ons. A modern PC has no ports that make it easy to communicate with your own add-on devices, and programming languages tend to have little or no built-in support for the ports that are present.

As explained in recent *Interface* articles, there is support for RS232C serial ports in Visual BASIC 2008, and in the free Express edition of this programming language. While it is true that most modern PCs do not actually have any serial ports, the virtual variety can be added using an inexpensive commercial add-on that connects to one of the PC's USB ports.

Alternatively, virtual serial ports can be built into your add-on projects, which then interface to the PC via a USB port. With suitable driver software installed, a virtual serial port can be used just like the genuine article when using Visual BASIC 2008 Express. This method of interfacing has been explored in recent Interface articles.

Visual BASIC 2010 Express

Things have inevitably moved on, and Visual BASIC 2008 has been replaced by Visual BASIC 2010. The Express Editions of Microsoft's programming languages have also moved on, and it is now Visual BASIC 2010 Express that is offered as a free download. Presumably, support for the 2008 version will be discontinued in due course, but it remains usable for as long as you have suitable hardware running a compatible operating system. Consequently, there is no necessity for existing users of the 2008 version to upgrade now, they will probably not have to upgrade for some years.

However, new users will have to download and use the 2010 version. I suppose we should look forward to new and 'improved' versions of programs, but new software often means new problems, and this has certainly been the case with recent upgrades to Visual BASIC. So, does the new version work as well as the old one, and does it have any advantages in the current context?

Although this is free software, it is not simple software. You need a reasonably competent computer in order to run it, and the minimum recommended hardware:

- 1.6GHz or faster processor (X86 or X64 type)
- 1024 MB RAM (1.5GB if running on a virtual machine)
- 3GB of available hard-disk space
- 5400 RPM hard-disk drive
- DirectX9-capable video card running at 1024 × 768 or higher display resolution

It has to be stressed that this is the minimum recommended for running any of the Visual Studio applications, and that something better than the bare minimum is likely to be better in use.

Any Windows operating system from Windows XP onwards is suitable. I found that it ran quite well on an ageing PC running under Windows XP with a 2.4GHz Pentium 4 processor and 1.5GB of memory. Visual BASIC 2010 Express will probably run on practically any computer that was capable of handling the previous version.

Download

Like the previous version, the new one involves a download of around 150 megabytes, which takes only two or three minutes with a good broadband connection, and is within reason for a competent dial-up connection. There are several Express Edition languages available, plus trials of the full Visual Studio products, so you have to take care that the right download is selected. At the time of writing, this is the web address of the download page:

www.microsoft.com/express/windows/

After left-clicking the link for Visual BASIC 2010 Express, you have to select the required language version, and a small program is then downloaded. This is the downloader and installer, and running it results in the main program being automatically downloaded and installed, with little or no intervention required by the user.

As far as I can ascertain, there is no disc version of the Express programs that can be purchased from Microsoft for a small handling fee. You either have to use this method, or download the massive ISO disc image for all the Express programs and then burn an installation DVD.

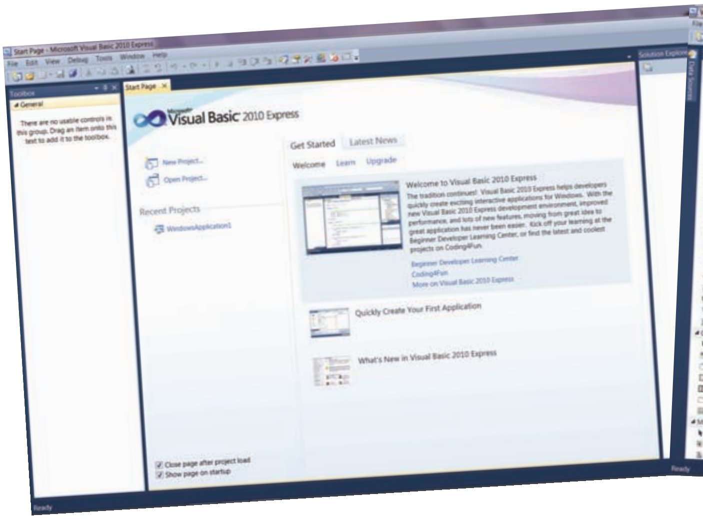


Fig.1. The initial screen of Visual BASIC 2010 Express is different to that of the previous version. Provided there is an active Internet connection, the up-to-date news about the program can be obtained via the Latest News button

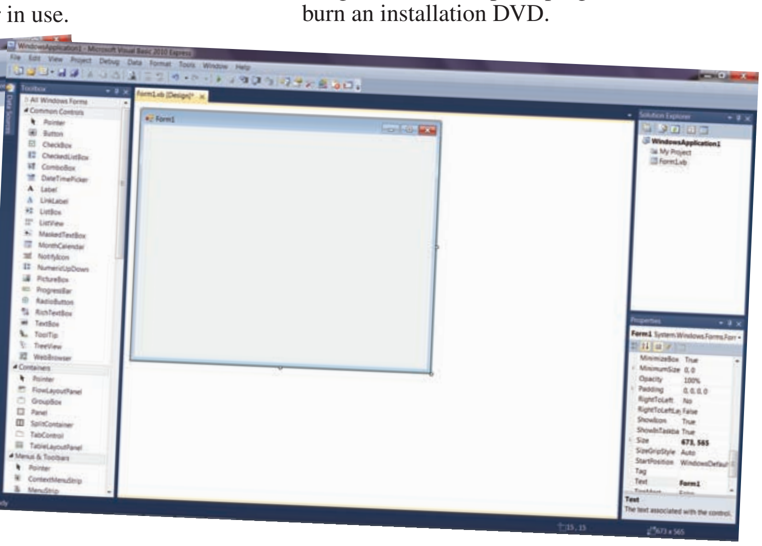


Fig.2. Things are much the same as before when writing a form-based program. The screen layout and menu structure have not been changed significantly

The installation of large Windows programs can be a time-consuming process, with several reboots being required, so do not be surprised if it takes nearly an hour before the program is ready for use! If your PC lacks the wherewithal to run the program, it is likely that the installation process will be aborted and an appropriate error message will be displayed. Apart from the slowness of the process, installation proved to be straightforward and the program ran without any problems on the test PC.

Time limit

An important point to note is that the Express versions of Microsoft programs, like the demonstration versions of the full products, are 30-day trial versions. They will only run for 30 days after installation unless they are registered. However, online registration is free, and is very straightforward if you already have some form of Microsoft account such as a Hotmail email address or a Windows Live account. It is otherwise necessary to create an account, and some basic personal information has to be provided when doing so.

Registration is done from within the program by going to the Help menu and selecting the Register Product option. The program will run indefinitely once the supplied registration number has been entered.

The initial screen of Visual BASIC 2010 Express (Fig.1) is different to the 2008 version. News about Microsoft programming languages is no longer displayed at start-up, but it can still be obtained via the Latest News button.

There are links for starting a new project or opening an existing one. It might be different with complex software, but simple programs written in Visual BASIC 2008 Express seem to open in the 2010 version without any difficulty, and without the need to go through a separate conversion process first. The same is not true of programs written in anything prior to the 2008 version.

Opting to start a new project gives the usual menu of project types, and selecting the Windows Form option produces the screen of Fig.2. This is much the same as the Visual BASIC 2008 equivalent, with the standard menu bar, etc. at the top, a palette of components on the left, the Properties and Explorer windows on the right, and the form in the main central panel. For once there seems to have been no wholesale redesign of the program, and it is used in much the same way as its predecessor. The menu structure has not been significantly altered.

Serial crop

Some form of component for interfacing to serial ports is a feature that has come, gone, and returned again in Visual BASIC. Crucially, with this upgrade the SerialPort component of the previous version has not been 'given the chop'. It is still included, and using real or virtual RS232C ports with this version of Visual BASIC is handled in exactly the same way as it was previously. A simple serial output program written in Visual BASIC 2008 Express loaded into the new version, compiled, and ran without any difficulties (Fig.3).

Drawing on the past

There are still no drawing components included as standard, making it necessary to either use normal programming techniques or visual add-ons in order to produce graphics. As explained in previous *Interface* articles, drawing components are very useful when producing software for your own hardware, such as computer-based test equipment, as they make it easy to produce virtual control knobs, slider switches, analogue displays, and the like.

Fortunately, like Visual BASIC 2008, the new version seems to be compatible with the free Power Packs 3 software add-on that includes three simple but very useful components for drawing lines and shapes. The Power Packs 3 add-on was already installed on the computer I used to test Visual BASIC 2010 Express, and it was recognised and used by the new installation.

The added components work normally with the new version of Visual BASIC (Fig.4). Although the Power Packs 3 software is not officially supported by Microsoft, it is written by Microsoft staff members and is available from Microsoft's website: **http://msdn.microsoft.com/en-us/vbasic/bb735936.aspx**.

Whether to upgrade

The improvements to the program seem to be minimal, and are mainly centred on the IDE (integrated development environment) rather than the core program. It is far from essential to upgrade to the new version if it will be only be used for writing software for PC-based projects, although for most users it would cost nothing to do so. Also, support for the previous edition will probably be phased out before too long, and this has already happened with the 2005 version. Where possible, it is usually better to use a current software product rather than one that has passed its 'use-by' date.

Looking on the bright side, this lack of change does at least mean that the program has not taken a step backwards. When trying out new versions of Visual BASIC I tend to find the old classic song 'There May be Trouble Ahead' going through my head, and with good reason.

Some previous upgrades to Visual BASIC have made it more difficult to write software for use with your own gadgets, or have required new add-on software to maintain the *status quo*. The change from Visual BASIC 6 to the first .NET version resulted in some fundamental changes in the programming language, and led to debates as to whether it was really Visual BASIC any more.

In this case, it seems to be possible to carry on using the SerialPort component and the Power Packs 3 software exactly as before. There have been no major changes to the programming language. Indeed, serial port software written using Visual BASIC 2008 Express seems to load quite happily into the new version where it can be modified and compiled without any problems.

Interfacing projects to a PC's USB port using the virtual serial port method should be viable for at least several years into the future. This remains the easiest way of interfacing your own circuits to a modern PC, and using Visual BASIC 2010 Express, the software side of things can be handled at no cost.

As far as I can ascertain, there are still no significant restrictions on the way in which the software produced can be distributed. Even commercial sale is still permitted, which is something that used to require the Pro version of the program at a cost of a few hundred pounds.

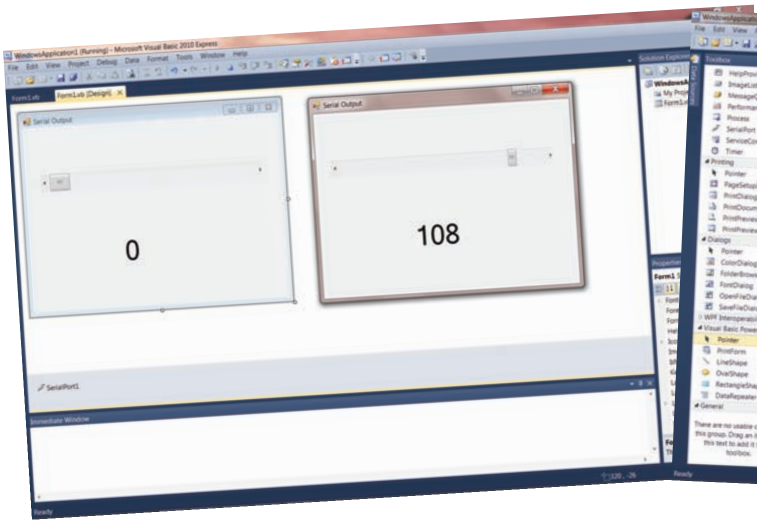


Fig.3. The SerialPort component is still present, and there seems to be no difficulty in loading and compiling Serial Port software produced using Visual BASIC 2008 Express. This is a simple program for outputting data to a serial port

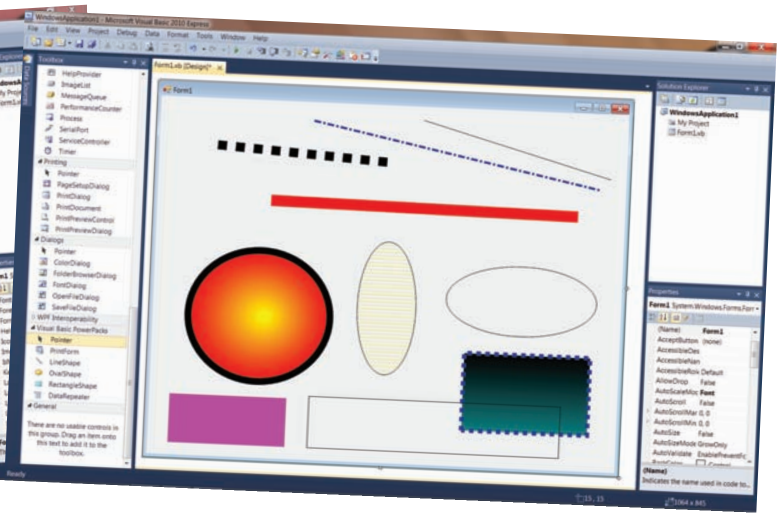
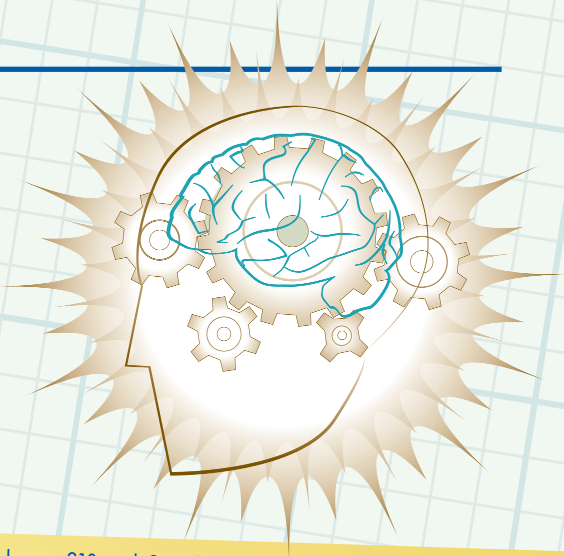


Fig.4. The components provided by the free Power Packs 3 add-on work properly with the new version of the program, and should be considered an essential addition. They make it easy to produce items such as virtual controls and meters

Ingenuity Unlimited

Our regular round-up of readers' own circuits

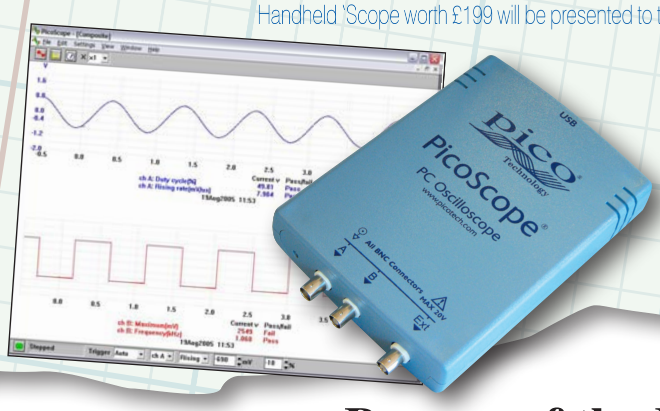


WIN A PICO PC-BASED OSCILLOSCOPE WORTH £799

- 200MHz Analogue Bandwidth Dual Channel Storage Oscilloscope
- Spectrum Analyser
- Frequency Meter
- Multimeter
- USB Interface.

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC-based oscilloscope could be yours.

After every 20 published IU circuits, Pico Technology will be awarding a PicoScope 3206 digital storage oscilloscope for the best IU submission. In addition a PicoScope 2105 Handheld 'Scope worth £199 will be presented to the runner up.



We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit designs, not simply mechanical, electrical or software ideas. Ideas must be the reader's own work and **must not have been published or submitted for publication elsewhere.**

The circuits shown have NOT been proven by us. **Ingenuity Unlimited** is open to ALL abilities, but items for consideration in this column should be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and include a full circuit diagram showing all component values. **Please draw all circuit schematics as clearly as possible.**

Send your circuit ideas to: Ingenuity Unlimited, Wimborne Publishing Ltd., 113 Lynwood Drive, Merley, Wimborne, Dorset BH21 1UU. Email: editorial@epemag.wimborne.co.uk.

Your ideas could earn you some cash **and a prize** !

Beware of the Runt pulse – *timeout*

MY home made digital radio clock, tuned to the NPL's standard date and time transmission on 60kHz, initially from Rugby now Anthorn, worked perfectly for years – but suddenly the display became chaotic.

The date and time code is transmitted every minute. The start of the code sequence is marked by a unique 500ms gap in the on/off signal; it is essential that the clock decoder should recognise this 'minute marker'. This is achieved in my clock using the circuit in Fig.1.

The two monostables IC1 and IC2 are clocked by the time code and generate 400ms and 600ms pulses to straddle the 500ms minute marker. The E-OR gate, IC3a, produces a 200ms pulse as 'data' to the D-type flip-flop IC4a. The code high pulse at 500ms clocks IC4 and sends it's Q1 high, signalling the start of the code sequence to the rest of the decoder.

I found that the Q outputs of IC1 and IC2 were OK, and that the output of the E-OR gate, IC3a, was – according to the 'scope traces – also OK. But, the Q output of IC4a was showing multiple highs every second.

Eventually, after further tests on a breadboard, it became clear that the data input to IC4a contained a 'runt pulse', although it was too short to show on the scope and even a logic probe could not detect it. This effect was probably due to the ageing of the two monostables (IC1 and IC2) in that although they were driven by the same clock, they were not triggering at exactly the same time. Putting a $0.1\mu F$ capacitor on the output of the E-OR gate, IC3a, damped this short pulse, but without adversely affecting the much longer code pulses, and the clock worked perfectly. But this quick and dirty fix was clearly not acceptable in a digital design. The eventual cure was to replace IC1 and IC2 with a 4098 precision dual monostable, with the same propagatiom delay in each half.

Stephen Stopford, London

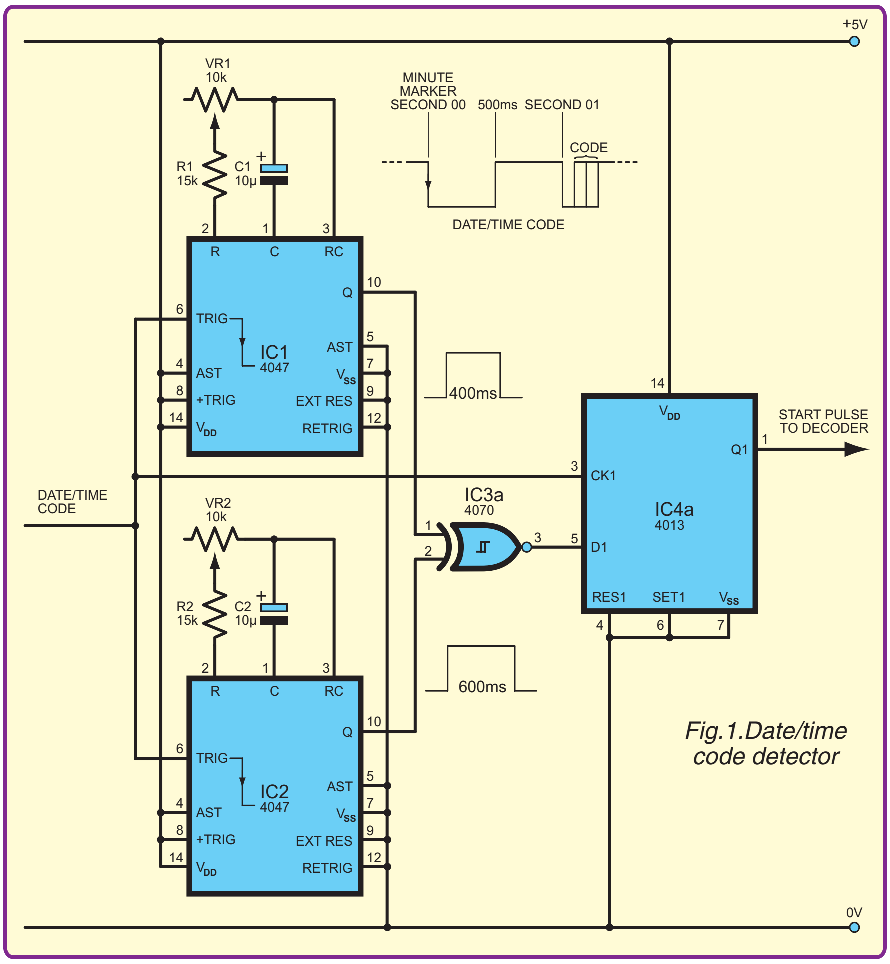


Fig.1.Date/time code detector

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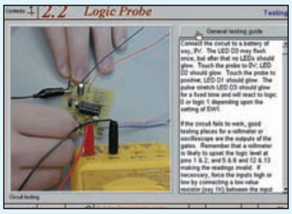
ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

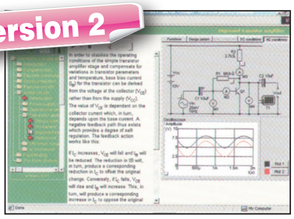


Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture, circuit simulation** and **p.c.b. design** software is included.
The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

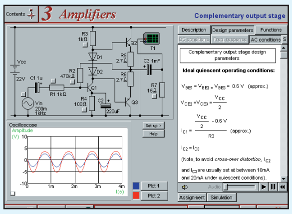
Version 2



Circuit simulation screen

Electronics Circuits & Components V2.0 provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals***: units and multiples, electricity, electric circuits, alternating circuits. ***Passive Components***: resistors, capacitors, inductors, transformers. ***Semiconductors***: diodes, transistors, op amps, logic gates. ***Passive Circuits. Active Circuits.*** *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams.
Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS

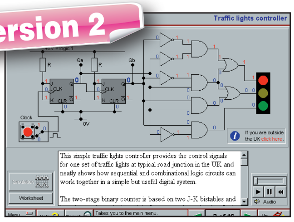


Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.
Sections on the CD-ROM include: ***Fundamentals*** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). ***Op Amps*** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. ***Amplifiers*** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). ***Filters*** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). ***Oscillators*** – 6 sections from Positive Feedback to Crystal Oscillators. ***Systems*** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

DIGITAL ELECTRONICS V2.0

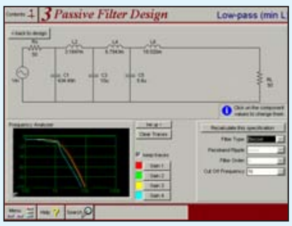
Version 2



Virtual laboratory - Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (above), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

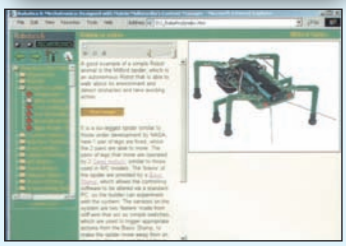
ANALOGUE FILTERS



Filter synthesis

Analogue Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev op.amp filters. This CD-ROM is being discontinued, **only the Hobbyist/Student version is now available**.

ROBOTICS & MECHATRONICS



Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student	**£45**	**inc VAT**
Institutional (Schools/HE/FE/Industry)	**£99**	**plus VAT**
Institutional 10 user (Network Licence)	**£249**	**plus VAT**
Site licence	**£499**	**plus VAT**

(UK and EU customers add VAT at 17.5% to 'plus VAT' prices)

PICmicro TUTORIALS AND PROGRAMMING

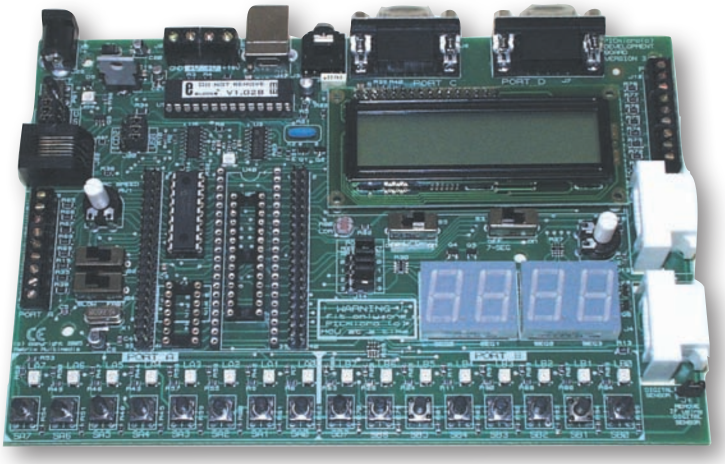
HARDWARE

VERSION 3 PICmicro MCU development board

Suitable for use with the three software packages listed below.

This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices from the 12, 16 and 18 series PICmicro ranges. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

- Makes it easier to develop PICmicro projects
- Supports low cost Flash-programmable PICmicro devices
- Fully featured integrated displays – 16 individual LEDs, quad 7-segment display and alphanumeric LCD display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- USB programmable
- Can be powered by USB (no power supply required)



£158 including VAT and postage, supplied with USB cable and programming software

SOFTWARE

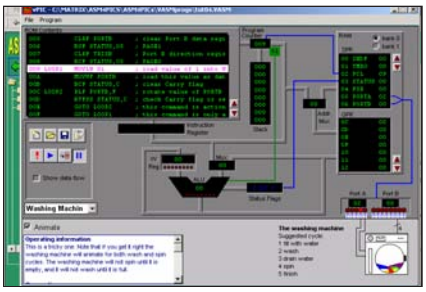
ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes.

The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller, this is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed, which enhances understanding.

● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.

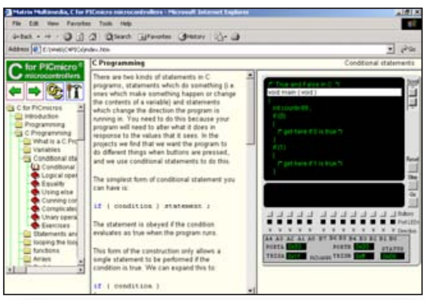


'C' FOR 16 Series PICmicro Version 4

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD-ROM contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



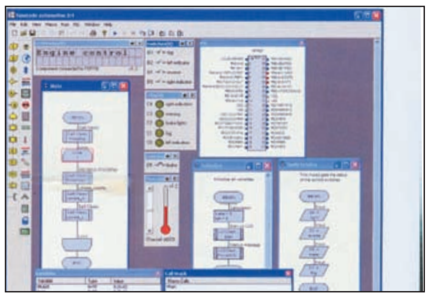
Minimum system requirements for these items: Pentium PC running, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.
Flowcode will run on XP or later operating systems

FLOWCODE FOR PICmicro V4

Flowcode is a very high level language programming system based on flowcharts. Flowcode allows you to design and simulate complex systems in a matter of minutes. A powerful language that uses macros to facilitate the control of devices like 7-segment displays, motor controllers and LCDs. The use of macros allows you to control these devices without getting bogged down in understanding the programming. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

- Requires no programming experience
- Allows complex PICmicro applications to be designed quickly
- Uses international standard flow chart symbols
- Full on-screen simulation allows debugging and speeds up the development process.
- Facilitates learning via a full suite of demonstration tutorials
- Produces ASM code for a range of 18, 28 and 40-pin devices
- 16-bit arithmetic strings and string manipulation
- Pulse width modulation
- I2C.

New features of Version 4 include panel creator, in circuit debug, virtual networks, C code customisation, floating point and new components. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)



PRICES

Prices for each of the CD-ROMs above are:

(Order form on next page)

(UK and EU customers add VAT at 17.5% to 'plus VAT' prices)

Hobbyist/Student	£45	inc VAT
Institutional (Schools/HE/FE/Industry)	£99	plus VAT
Institutional/Professional 10 user (Network Licence)	£350	plus VAT
Site Licence	£699	plus VAT
Flowcode Institutional (Schools/HE/FE/Industry)	£149	plus VAT
Flowcode 10 user (Network Licence)	£399	plus VAT
Flowcode Site Licence	£799	plus VAT

SPECIAL PACKAGE OFFER

TINA Pro V7 (Basic) + Flowcode V3 (Hobbyist/Student)

£68.00 inc. VAT and p&p

TINA Analogue, Digital, Symbolic, RF, MCU and Mixed-Mode Circuit Simulation, Testing and PCB Design

TINA Design Suite is a powerful yet affordable software package for analysing, designing and real time testing analogue, digital, MCU, and mixed electronic circuits and their PCB layouts. You can also analyse RF, communication, optoelectronic circuits, test and debug microcontroller applications.

Enter any circuit (up to 100 nodes) within minutes with TINA's easy-to-use schematic editor. Enhance your schematics by adding text and graphics. Choose components from the large library containing more than 10,000 manufacturer models. Analyse your circuit through more than 20 different analysis modes or with 10 high tech virtual instruments. Present your results in TINA's sophisticated diagram windows, on virtual instruments, or in the live interactive mode where you can even edit your circuit during operation.

Customise presentations using TINA's advanced drawing tools to control text, fonts, axes, line width, colour and layout. You can create, and print documents directly inside TINA or cut and paste your results into your favourite word- procesing or DTP package.

TINA includes the following Virtual Instruments: Oscilloscope, Function Generator, Multimeter, Signal Analyser/Bode Plotter, Network Analyser, Spectrum Analyser, Logic Analyser, Digital Signal Generator, XY Recorder.

***Flowcode V3** (Hobbyist/Student) – For details on Flowcode, see the previous page.*

This offer gives you two seperate CD-ROMs – the software will need registering (FREE) with Designsoft (TINA) and Matrix Multimedia (Flowcode), details are given within the packages.

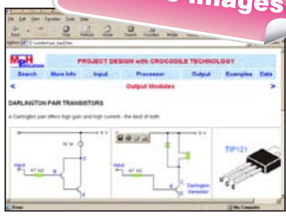
Get TINA + Flowcode for a total of just £68, including VAT and postage.

PROJECT DESIGN WITH CROCODILE TECHNOLOGY

An Interactive Guide to Circuit Design

Over 150 pages
Over 600 images

An interactive CD-ROM to guide you through the process of circuit design. Choose from an extensive range of input, process and output modules, including CMOS Logic, Op-Amps, PIC/PICAXE, Remote Control Modules (IR and Radio), Transistors, Thyristors, Relays and much more. Click Data for a complete guide to the pin layouts of i.c.s, transistors etc. Click More Information for detailed background information with many animated diagrams.
Nearly all the circuits can be instantly simulated in Crocodile Technology (not included on the CD-ROM) and you can customise the designs as required.*

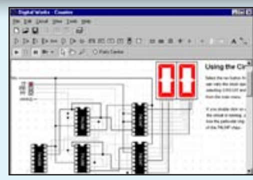


WHAT'S INCLUDED
Light Modules, Temperature Modules, Sound Modules, Moisture Modules, Switch Modules, Astables including 555, Remote Control (IR & Radio), Transistor Amplifiers, Thyristor, Relay, Op-Amp Modules, Logic Modules, 555 Timer, PIC/PICAXE, Output Devices, Transistor Drivers, Relay Motor Direction & Speed Control, 7 Segment Displays.Data sections with pinouts etc., Example Projects, Full Search Facility, Further Background Information and Animated Diagrams.
Runs in Microsoft Internet Explorer
All circuits can be viewed, but can only be simulated if your computer has Crocodile Technoloy version 410 or later. A free trial version of Crocodile Technology can be downloaded from: **www.crocodile-clips.com. Animated diagrams run without Crocodile Technology.*

Single User £39.00 inc. VAT.
Multiple Educational Users (under 500 students) £59.00 plus VAT. Over 500 students £79.00 plus VAT.
(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 2000/ME/XP, mouse, sound card, web browser.

DIGITAL WORKS 3.0



Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability ● Software for simulating digital logic circuits ● Create your own macros – highly scalable ● Create your own circuits, components, and i.c.s ● Easy-to-use digital interface ● Animation brings circuits to life ● Vast library of logic macros and 74 series i.c.s with data sheets ● Powerful tool for designing and learning.

Hobbyist/Student £45 inc. VAT.
Institutional £99 plus VAT.
Institutional 10 user £249 plus VAT.
Site Licence £599 plus VAT.

ELECTRONIC COMPONENTS PHOTOS

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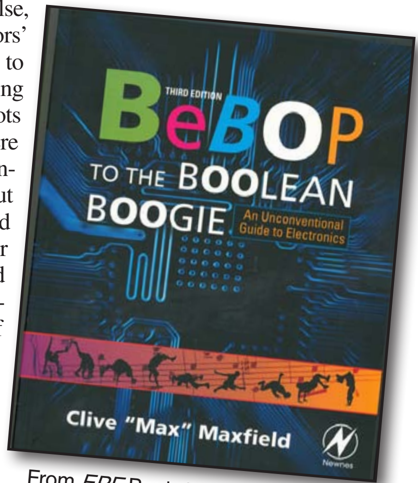
Max's Cool Beans

By Max The Magnificent

I'm an engineer by trade. I drifted into writing by accident. Now, freelance writing is what I do as a job and – believe it or not – I really enjoy it! I especially enjoy taking a complex technical subject and writing about it in such a way that my readers jump up and down with excitement exclaiming: "Ah, now I understand!"

Apart from anything else, writing has 'opened doors' to me and enabled me to travel to many fascinating countries and to meet lots of interesting people. There are numerous fantastic engineers in the world, but many get 'typecast' and end up spending their working lives trapped in poky cubicles far removed from the light of day ("They don't let us out very often," as the somewhat-disturbed scientist said in the movie *Independence Day*). I could easily have ended up one of their number, but writing has enabled me to run wild and free (cue the theme song from *Born Free*).



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The down-side to all of this is that, over the years, I have grown to be very sensitive to errors in other folks' writings. I'm not talking about convoluted questions of grammar that would be of interest only to scholars of the English language – I'm talking about really basic things, like people confusing your and you're, or its and it's, or there and their and they're. Apart from anything else, let's suppose that someone sends me an email saying something like 'I think your an idiot!' Well, all I can say is that the end result is almost certainly not what my correspondent was hoping for.

It doesn't matter who you are or how well-educated you are – at some time or another almost everyone runs into problems relating to grammar and punctuation. Why do we care? Well, incorrect grammar, punctuation, or usage can detract from the value and usability of your writings. You could be explaining something incredibly interesting and really useful, but your reader may become distracted by your incorrect use of the words; there and their, for example, and the significance of what you are trying to impart may be lost.

In one worst-case scenario (we always say 'worst-case' – never 'worse-case'), there may be so many minor errors in your writings that your readers may simply give up, mistakenly assuming that if you don't know the difference between its and it's, then you probably don't know what you are talking about on a technical level either.

Good grief

Good grief! If you had asked me when I was a young engineer if I would one day be writing an article about grammar and punctuation... I would have laughed my socks off. But wait, it gets worse, because I've come to realise that I can actually make some money offering half-day 'Writing for Success' seminars to companies here in town (Huntsville, Alabama, USA – I moved here for the nightlife – that's a little Alabama joke).

Of course, this means that I have to do a little research to make sure I have my facts correct. The funny thing is that I'm really enjoying this because I'm learning so much. Take the difference between its and it's, for example. I think that most folks would have a knee-jerk reaction of: 'Oh, I know all about that!' Really? Well, I actually discovered some interesting historical trivia here.

As a simple example, consider the way we form the possessives of singular nouns, which is to add 's (that is, an apostrophe followed by an s); for example:

- The dog's dinner. {Food belonging to the dog}
- The boy's ball. {A ball belonging to the boy}

Now, in the same way that the feminine pronoun she has the possessive form her, and the masculine pronoun he has the possessive form his, the neutral pronoun it has the possessive form its. Thus, we say things like:

- This chair has lost its leg.
- The car lost its power.
- The committee published its decision.

Observe that we don't use an apostrophe here – instead we just slap an s on the end. If we do include an apostrophe, then this is to form a contraction; for example:

- It's a mystery to me {The contraction of it is}
- It's been great to meet you. {The contraction of it has}

When we are first taught this at school, we learn it by rote and it all seems to make sense, but do things really have to be this way? In the case of regular nouns, the 's (an apostrophe followed by an s) form is successful in covering both the possessive and contraction cases; for example:

- Frank's hat is on his head {The hat belongs to Frank}
- Frank's going to the pool. {Contraction of Frank is}

So you might wonder why it's shouldn't follow the same rule – that is, to act both as a possessive and a contraction and leave it up to the reader to decide the actual meaning from the context.

'Tis a good brief

Actually, the way in which possessive pronouns were used remained something of a muddle until around the beginning of the 1800s. Prior to that time, some folks used apostrophised forms while others favored un-apostrophised versions. In fact, the contraction of it is used to be the word 'tis; meanwhile, it's was commonly used as the possessive of it – that is, the exact opposite of the way we do things today!

Later, as the use of the word 'tis faded away, it's was increasingly used to represent both the possessive and the contraction, leaving it up to the reader to determine the meaning from the context. Eventually, sometime during the early part of the 19th century, grammarians settled on the somewhat arbitrary decision that its would be used to represent the possessive while it's would be used to represent the contraction. And that's where things stand today.

I tell you, I learn something new every day (isn't life wonderful?)! Until next time, have a good one!

Check out 'The Cool Beans Blog' at www.epemag.com

Catch up with Max and his up-to-date topical discussions

READOUT

Email: editorial@wimborne.co.uk

Matt Pulzer addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

All letters quoted here have previously been replied to directly

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☆ LETTER OF THE MONTH ☆

SMDs, lead and reworking

Dear Editor

Thank you for the very interesting piece *How To Solder Surface Mount Devices* in the July issue. Perhaps I can offer a few amplifications and clarifications?

First, I should mention that because of the WEEE (Waste Electrical and Electronic Equipment) directive in European law, it is now against the rules to use solder formulations containing lead in new assemblies (except for a very few exemptions). Unfortunately, the lead-free solders are quite tricky to use because they require higher temperatures, which can only be risked for shorter times (to avoid damaging the components) and are much less tolerant of contamination than lead solders – particularly contamination from lead, so that means a different soldering iron for a start!

This applies to hand soldering through-hole components just the same, and I see it as a major problem for the enthusiast. For the hobbyist, I would recommend turning a blind eye to the regulations and continue using lead solder, but it may become difficult to obtain. It should still be available for repair work, for which lead solder is permitted, since lead-free recipes would be unworkable because of the contamination issue I mentioned earlier.

Lead-free solder is also reportedly more susceptible to dendrite shorts: after a circuit board (particularly with fine-pitch IC pins) has been in service for many months, it can fail due to fine conductive needles growing across the gaps. Personally, I think we've thrown the baby out with the bath water – lead in solder is so useful it would be better to capture it on disposal than ban it from being used in the first place – hobby-horse over.

The article mentions that the surface tension in the solder will pull the solder paste onto the IC pads and clear the gaps (as long as you are sparing with the paste), but it does not say that a vital ingredient in this process is the solder resist layer. This is the green coating shown in the photos, screen-printed on to the PCB (avoiding the places you actually want to solder). It repels molten solder so it helps the reflow process to 'clear the gaps' as it were. All commercial PCBs have a solder resist layer, and I don't expect a hobbyist to be able to make PCBs with fine-pitch surface mount pads at home, so the omission is not serious one.

I have hand soldered (and desoldered) 0.05-inch pitch SOICs, but I think I would draw the line at that. I prefer a fine-pointed conical tip for my soldering iron, the bits you can get with a miniature tip are too fragile and have too poor a heat transfer. For finer pitches, an alternative to the oven would be a hot air gun, and specialist equipment is not out of the question for a small workshop budget. For a hobbyist you might just get away with an electric hot-air paint stripper, carefully wafted over the area (but the components would have to be glued or clamped down to stop them being blown off).

As for rework – it can be done! A quick warm-up with a paint stripper and a sharp tap, and all the components fall off. To reuse the PCB, all the remaining solder has to be removed from the pads with desoldering braid (the pads must be absolutely level) and the same goes for any solder residue on the component leads (and the components do generally survive). Obviously, a lot more care is needed if you only want to get one component off the board.

Keep up the good work.

Ken Wood, by email

Thank you Ken, a most useful addition to the article. I tend to agree with you about lead in solder for the hobbyist. While lead is toxic as well as being a valuable resource, the hobbyist contribution to pollution and resource degradation is so small as to be irrelevant. Industry on the other hand, consumes huge and growing amounts of solder, and far too much ends up in the ground for my liking. Better still, as you point out, is recycling.

Stripboard projects please

Dear Editor

I'm sure many of your readers, like me, are interested in constructing projects using stripboard.

Since the first issue of *Everyday Electronics* several decades ago, *EPE* has, without question, set the standard in stripboard construction. Sadly, however, this appears to be a thing of the past, especially with *EPE* projects becoming more and more complex.

Both methods of construction have their place, but one of them is better placed than the other in the absence of ready-made PC boards, such as the ones purchased through *EPE*. The alternative, when attempting a project from a circuit diagram with a PC board in mind is finding a company that will make a one-off circuit board at a reasonable price using the full-size copper master pattern.

This brings us to constructing projects with stripboard, which for smallish projects has many advantages. It requires no preparation other than cutting to size and is readily available and very reasonably priced. The only problem is that when converting a circuit diagram to stripboard it is not as easy as *EPE* make it look. Bearing this in mind, would it be practical for *EPE* to run a tutorial on this subject?

Although not all projects published in *EPE* lend themselves to stripboard construction, some of them do. So, to help 'stripboard followers' it would be of benefit if *EPE* could dedicate a little space in such projects to print the stripboard component layout as well as the PC board.

EPE started the ball rolling when it comes to stripboard construction, and when you consider that many of your younger readers, who are now just starting out in electronics, were not even born when stripboard was first used, then such an addition may help

them work on your projects from those early days,

Keep up the excellent work

Harry Mellor, by email

Good points Harry, and thank you for your kind words about EPE. *We have not abandoned stripboard altogether, but the increasing availability of reasonably priced PC boards, as well as the complexity of some projects, does mean that they are used much less than before. Like you, I regret this, and we will try and consider reintroducing the occasional stripboard-based project.*

Unfortunately, publishing a complimentary stripboard as an alternative to PC boards would require all authors to build, test and troubleshoot two versions of a project and I doubt we will going down that route, however useful it would be in practice. That said, I do like your idea of some guidance on stripboard design and construction techniques, and will suggest this to Robert Penfold as a future Practically Speaking *topic.*

Google Maps Navigation

Dear Editor

I read Alan Winstanley's *Net Work* article in the May 2010 issue of *EPE*. In it, he speculates that Street View functionality will soon be present in sat nav systems and mobile phones. He may be interested to know that this has indeed already happened. Google released the beta version of the Google Maps Navigation for Android mobile phones late last year. It is a free, Google-Maps-based sat nav system, which also incorporates Street View and runs on Android-powered mobile phones. Unfortunately, the service is currently limited to the US only. Not surprisingly, the stock price of several major navigation system manufacturers took a hit when Google announced this!

The Google Maps Navigation website can be found at: **www.google.com/mobile/navigation**.

Amr Bekhit, by email

Alan Winstanley replies…

Hi Amr, and thanks for the follow-up – as you rightly say, Google Maps Navigation is only available in the US for now.

Tying Street View together with GPS and Google Maps gives rise to some extremely interesting new concepts. In the June Net Work *I mentioned Google Goggles and Plink, the UK-designed visual search application that has been purchased by Google to further develop Google Goggles: you'll eventually be able to identify your location simply by pointing your Android-based cameraphone at a building, which the mobile application will 'scan' and 'recognise'. Your phone will tell you where you are, and where to go.*

I'll keep a close eye on Android apps when they roll out across the UK, thanks for the pointer and the link.

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Net Work

Alan Winstanley

The vanishing virus

An acquaintance recently took the plunge and upgraded his dial-up Internet to ADSL. He signed up for a combined broadband and phone tariff branded and sold by the Post Office. However, on the appointed day his PC stubbornly refused to connect to the Internet, so I was asked to lend a hand. I wondered what disasters awaited me as I knocked on his front door…

The Post Office had supplied a compact single-port Zyxel router (by post, naturally). None of the LEDs on the moribund router were illuminated, which gave me an obvious clue about the problem: either there was no power or no ADSL signal! The mains adaptor was working, but the router was plugged into the same motley array of DIY extension leads previously used for his 56k modem, so the first step was to eliminate the extension leads by plugging the new router directly into the wall socket via a microfilter. The ADSL light still resolutely refused to glow – and a quick call to the Post Office revealed that the ADSL would only be activated ‘some time today’.

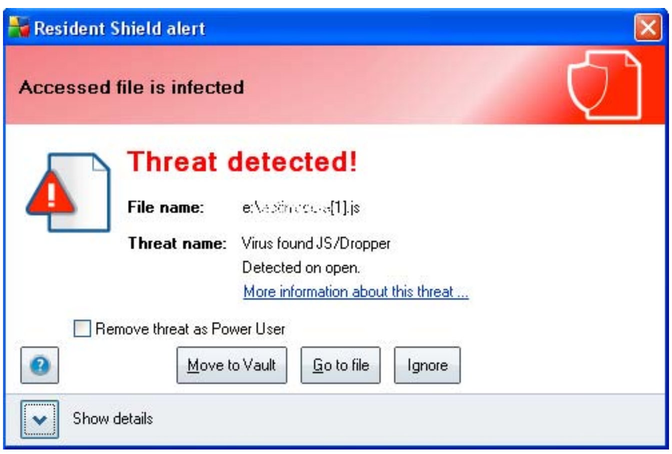
Meantime, I discovered that the AVG Anti Virus that I had previously installed was nowhere to be found. My friend couldn’t elaborate on the disappearance of ‘that funny little symbol [the AVG icon] near the Windows clock’. Before going any further, I re-installed AVG via a USB memory stick, and when the ADSL sprang into life right on cue, my first port of call was the AVG website at **http://free.avg.com/** to update the anti-virus database.

Then I installed Malwarebyte’s AntiMalWare, which should only be downloaded directly from **www.malwarebytes.org**. As I’ve warned many times before in *Net Work*, googling for such products merely lures unsuspecting surfers into downloading all sorts of fake malware programs from bogus websites, which often introduces even more problems. After a full PC scan and with basic protection finally in place, I configured Outlook Express to fetch GMail (check Google Help at **http://tinyurl.com/bt8l2**) and left my friend elated at the prospect of surfing with his new always-on broadband Internet connection.

Digging deep

Some anti-virus programs have added features (such as F-Secure DeepGuard) that analyse files in real-time in search of unusual patterns of behaviour. This consumes even more processing power and can bring an elderly PC to its arthritic knees. My current anti-virus choice is F-Secure 2010, but when email is being scanned (even in the background) the whole PC freezes briefly every ten minutes, which has become such a nuisance that I only fetch mail manually when I’m working in ‘production mode’.

The fact that files are not scanned in real-time ‘on the hoof’ isn’t so much of a concern, provided that users are mindful that infected files may lie dormant on a system. They can also wriggle into the System Restore area, which is how a supposedly cleansed system can become reinfected. The anti-virus system will, hopefully, detect such files when they are executed and offer to quarantine them. It’s wise to scan an entire system periodically, and sure enough my F-Secure recently found four such infected spam files lying dormant in my email attachments folder.



AVG triggered an alarm similar to this when visiting a potentially infected website that other anti-virus products ignored.

Even when a commercial anti-virus product is installed, some recent practical experience highlights the problem of virus signatures being recognised by some anti-virus packages but not others. Some visitors to an e-commerce site that I manage were being greeted by a pop-up window warning them of a possible virus infection. I could not replicate this problem using Norton Anti Virus or F-Secure. Eventually, I found a PC that ran AVG, so I visited the website in question, and my heart sank when I saw an ominous warning pop into view, telling me not to proceed due to the presence, it claimed, of a Trojan on the website.

The warnings related to two Javascript files which were part of the core script files utilised by commercial e-commerce software. My initial thought was that the web server must have been hacked, but what concerned me was that only AVG Anti Virus had detected it. Was this a ‘false positive’? I compared the reported Javascript files with the program’s originals and saw that extra code had indeed been tacked on at the end. This could only have happened through outside interference.

Then I checked several other websites operated by the same business, and exactly the same thing happened: visitors to those e-commerce sites who used AVG received a Trojan Dropper virus warning. It was as though all the company’s websites had been hacked into.

The ISP searched the server logs for the past month and reported that someone originating in Germany had repeatedly connected to the affected websites and had overwritten some key files with ones that contained extra Trojan code. Our first step was to urgently change the FTP logins for each site, and then reinstall the e-commerce software on the servers. The AVG warnings then disappeared and normal service resumed.

Eeek-commerce

It is astonishing that anybody would hack into an obscure e-commerce product in this way, never mind manage to upload them to the live website via FTP. I sent a sample of the suspicious Javascipt file to AVG, who stated that according to them the Javascript files were indeed infected, but this leaves a minor nagging doubt given that other reputable anti-virus products did not pick up the supposed infection when visiting the website.

There have been no further problems since reinstalling the e-commerce software, but it is a chilling reminder of the hazards that every Internet user now faces: keyloggers, Trojans, fake websites, ‘social engineering’ scams and cybercrime are very much a part of our experience, and we must be more vigilant than ever. So don’t follow the example of my acquaintance with his Post Office broadband: ensure that your anti-virus is running and up to date, and periodically scan your system with MalwareBytes or Spybot Seek & Destroy (a 15Mb download from **www.safer-networking.org only**). Maybe it’s full marks for AVG, but a black mark for other products.

You can Email me at: **alan@epemag.demon.co.uk** or write to the editor at: **editorial@epemag.wimborne.co.uk**.

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Why not turn that anonymous grey tower, that is the heart of your computer system, into a source of visual wonderment and fascination. To start, you need to change the case or some case panels for ones that are transparent. This will then allow the inside of your computer and it's working parts to be clearly visible.

There are now numerous accessories that are relatively inexpensive and freely available, for those wishing to customise their PC with added colour and light. Cables and fans can be made to glow, interior lights can be added, and it can all be seen to good effect through the transparent case. Exterior lighting and many other attractive accessories may also be fitted.

This, in essence, is case modding or PC Customising as it is sometimes called and this book provides all the practical details you need for using the main types of case modding components including:- Electro luminescent (EL) 'go-faster' stripes: Internal lighting units: Fancy EL panels: Data cables with built-in lighting: Data cables that glow with the aid of 'black' light from an ultraviolet (UV) tube: Digital display panels: LED case and heatsink fans: Coloured power supply covers.

192 pages + CD-ROM **Order code BP542** **£8.99**

ROBOT BUILDERS COOKBOOK
Owen Bishop

This is a project book and guide for anyone who wants to build and design robots that work first time.

With this book you can get up and running quickly, building fun and intriguing robots from step-by-step instructions. Through hands-on project work, Owen introduces the programming, electronics and mechanics involved in practical robot design-and-build. The use of the PIC microcontroller throughout provides a painless introduction to programming – harnessing the power of a highly popular microcontroller used by students, hobbyists and design engineers worldwide.

Ideal for first-time robot builders, advanced builders wanting to know more about programming robots, and students tackling microcontroller-based practical work and labs.

The book's companion website at http://books.elsevier.com/companions/9780750665568 contains: downloadable files of all the programs and subroutines; program listings for the Quester and the Gantry robots that are too long to be included in the book.

366 pages **Order code NE46** **£26.00**

NEWNES INTERFACING COMPANION
Tony Fischer-Cripps

A uniquely concise and practical guide to the hardware, applications and design issues involved in computer interfacing and the use of transducers and instrumentation.

Newnes Interfacing Companion presents the essential information needed to design a PC-based interfacing system from the selection of suitable transducers, to collection of data, and the appropriate signal processing and conditioning.

Contents: Part 1 – Transducers; Measurement systems; Temperature; Light; Position and motion; Force, pressure and flow. Part 2 – Interfacing; Number systems; Computer architecture; Assembly language; Interfacing; A to D and D to A conversions; Data communications; Programmable logic controllers; Data acquisition project. Part 3 – Signal processing; Transfer function; Active filters; Instrumentation amplifier; Noise; Digital signal processing.

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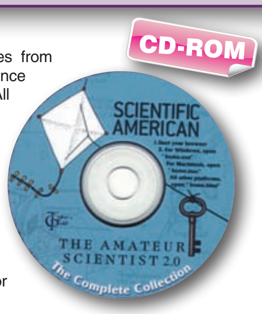

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OSCILLOSCOPES – FIFTH EDITION
Ian Hickman

Oscilloscopes are essential tools for checking circuit operation and diagnosing faults, and an enormous range of models are available.

This handy guide to oscilloscopes is essential reading for anyone who has to use a 'scope for their work or hobby; electronics designers, technicians, anyone in industry involved in test and measurement, electronics enthusiasts . . . Ian Hickman's review of all the latest types of 'scope currently available will prove especially useful for anyone planning to buy – or even build – an oscilloscope.

The contents include a description of the basic oscillscope; Advanced real-time oscilloscope; Accessories; Using oscilloscopes; Sampling oscilloscopes; Digital storage oscilloscopes; Oscilloscopes for special purposes; How oscilloscopes work (1): the CRT; How oscilloscopes work (2): circuitry; How oscilloscopes work (3): storage CRTs; plus a listing of Oscilloscope manufacturers and suppliers.

288 pages — **Order code NE37** — **£36.99**

ELECTRONIC TEST EQUIPMENT HANDBOOK
Steve Money

In most applications of electronics, test instruments are essential for checking the performance of a system or for diagnosing faults in operation, and so it is important for engineers, technicians, students and hobbyists to understand how the basic test instruments work and how they can be used.

The principles of operation of the various types of test instrument are explained in simple terms with a minimum of mathematical analysis. The book covers analogue and digital meters, bridges, oscilloscopes, signal generators, counters, timers and frequency measurement. The practical uses of these instruments are also examined.

206 pages — **Order code PC109** — **£9.95**

UNDERSTANDING ELECTRONIC CONTROL SYSTEMS
Owen Bishop

Owen Bishop has produced a concise, readable text to introduce a wide range of students, technicians and professionals to an important area of electronics. Control is a highly mathematical subject, but here maths is kept to a minimum, with flow charts to illustrate principles and techniques instead of equations.

Cutting edge topics such as microcontrollers, neural networks and fuzzy control are all here, making this an ideal refresher course for those working in Industry. Basic principles, control algorithms and hardwired control systems are also fully covered so the resulting book is a comprehensive text and well suited to college courses or background reading for university students.

The text is supported by questions under the headings Keeping Up and Test Your Knowledge so that the reader can develop a sound understanding and the ability to apply the techniques they are learning.

228 pages — **Order code NE35** — **£36.99**

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FULL COLOUR COMPUTING BOOKS

HOW TO FIX YOUR PC PROBLEMS — **R.A. Penfold**

What do you do when your laptop or desktop stops working properly. Do you panic, try to find the answer on the page of fault finding tips you may find at the back of the manufacturers manual. Or do you spend hours trying to get through to a telephone helpline or waste even more time waiting for an email reply from a helpdesk.

Well help is now at hand! This book will assist you in identifying the type of problem, whether it's hardware, software or a peripheral that is playing up? Once the fault has been identified, the book will then show you how to go about fixing it. This book uses plain English and avoids technical jargon wherever possible. It is also written in a practical and friendly manner and is logically arranged for easy reference.

The book is divided into four main sections and among the many topics covered are: Common problems with Windows Vista operating system not covered in other chapters. Also covers to a lesser extent Windows XP problems. Sorting out problems with ports, peripherals and leads. Also covers device drivers software and using monitoring software. Common problems with hard disc drives including partitioning and formatting a new drive. Using system restore and recovering files. Also covers CD-ROM and Flash drives. Common problems with sound and video, including getting a multi-speaker system set up correctly.

An extremely useful addition to the library of all computer users, as you never know when a fault may occur!

Printed in full colour on high quality non-refective paper

128 pages — **Order code BP705** — **£8.49**

AN INTRODUCTION TO WINDOWS VISTA — **P.R.M. Oliver and N. Kantarris**

If you have recently bought a new desktop or laptop it will almost certainly have Windows as its operating system. Windows Vista manages the available resource of a computer and also 'controls' the programs that run on it.

To get the most from your computer, it is important that you have a good understanding of Vista. This book will help you acheive just that. It is written in a friendly and practical way and is suitable for all age groups from youngsters to the older generation. It has been assumed that Vista is installed and running on your computer.

Among the numerous topics explained are: The Vista environment with its many windows. How to organise your files, folders and photos. How to use Internet Explorer for your web browsing. How to use Microsoft Mail for your emails. How to control your PC and keep it healthy. How to use Vista's Accessibility features if you have poor eye sight or difficulty in using the keyboard or mouse. And much more besides....

With the help of this book you will easily and enjoyably gain a better understanding of Microsoft's amazing Windows Vista operating system.

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120 pages — **Order code BP703** — **£8.49**

COMPUTING WITH A LAPTOP FOR THE OLDER GENERATION — **R.A. Penfold**

Laptop computers have rapidly fallen in price, increased in specification and performance and become much lighter in weight. They can be used practically anywhere, then stored away out of sight. It is therefore, not surprising that laptop sales now far exceed those of desktop machines and that they are increasingly becoming the machine of choice for the older generation.

You may want to use your laptop as your main computer or as an extra machine. You may want to use your laptop on the move, at home, at work or on holiday. Whatever your specific requirements are, the friendly and practical approach of this book will help you to understand and get the most from your laptop PC in an easy and enjoyable way. It is written in plain English and wherever possible avoids technical jargon.

Among the many topics covered are: Choosing a laptop that suits your particular needs. Getting your new computer set up properly. Customising your computer so that it is optimised for your particular needs. Setting up and dealing with user accounts. Using the Windows 'Ease of Access Center'. Optimising the life and condition of your battery. Keeping the operating system and other software fully up-to-date. Troubleshooting common problems. Keeping your computer and data safe and secure. And much more besides...

Even though this book is written for the older generation, it is also suitable for anyone of any age who has a laptop or is thinking of buying one. It is written for computers that use Windows Vista as their operating system but much will still apply to Windows XP machines. Printed in full colour on high quality non-refective paper

120 pages — **Order code BP702** — **£8.49**

AN INTRODUCTION TO EXCEL SPREADSHEETS — **Jim Gatenby**

The practical and friendly approach of this book will help newcomers to easily learn and understand the basics of spreadsheets. This book is based on Microsoft's Excel 2007 spreadsheet, but much of the book will still apply to earlier versions of Excel. The book is written in plain English, avoiding technical and mathematical jargon and all illustrations are in full colour. It is suitable for all age groups from youngsters to the older generation.

Among the many topics explained are how to: Install the software. Use the exciting new features of Excel 2007. Create and use a spreadsheet. Enter, edit and format text, numbers and formulae. Insert and delete columns and rows. Save and print a spreadsheet. Present the information on a spreadsheet as a graph or chart. Manage and safeguard Excel files on disc. Use Excel as a simple database for names and addresses.

This book will help you to quickly gain confidence and get to grips with using spreadsheets. In fact, you will wonder how you ever managed without them.

Printed in full colour on high quality non-reflective paper.

118 pages — **Order code BP701** — **£8.49**

AN INTRODUCTION TO DIGITAL PHOTOGRAPHY WITH VISTA — **R.A. Penfold**

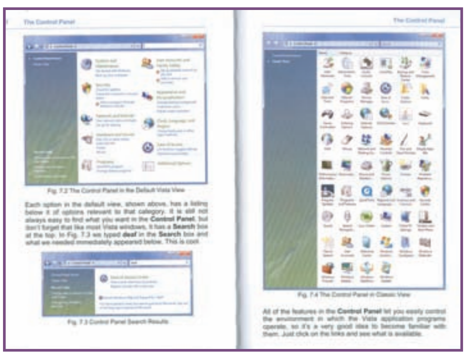
The friendly and practical approach of this book will help newcomers to digital photography and computing to easily learn the basics they will need when using a digital camera with a laptop or desktop PC. It is assumed that your PC uses Windows Vista, however, if it is a Windows XP machine the vast majority of this book will still apply. The book is written in plain English, avoiding technical jargon and all illustrations are in full colour. It is suitable for all age groups from youngsters to the older generation.

Among the many topics explained are how to: Understand the basic features of a digital camera. Transfer photographs from your digital camera to your computer. View your photographs. Save, sort and file your photographs. Manipulate, crop and carry out simple corrections to your photographs. Copy your photographs on to CD or DVD. Print your photographs. Share images with family and friends anywhere in the world by email or with an online album.

This book will help you quickly get to grips with, gain confidence and expand your horizons in the fascinating hobby of digital photography.

Printed in full colour on high quality non-reflective paper.

120 pages — **Order code BP700** — **£8.49**



PROJECT BUILDING

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold

Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different.

The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

Temporarily out of print

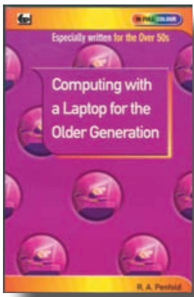
BUILDING VALVE AMPLIFIERS
Morgan Jones

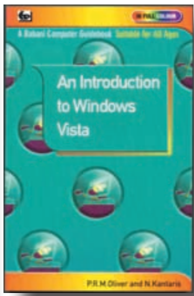
The practical guide to building, modifying, fault-finding and repairing valve amplifiers. A hands-on approach to valve electronics – classic and modern – with a minimum of theory. Planning, fault-finding, and testing are each illustrated by step-by-step examples.

A unique hands-on guide for anyone working with valve (tube in USA) audio equipment – as an electronics experimenter, audiophile or audio engineer.

Particular attention has been paid to answering questions commonly asked by newcomers to the world of the vacuum tube, whether audio enthusiasts tackling their first build, or more experienced amplifier designers seeking to learn the ropes of working with valves. The practical side of this book is reinforced by numerous clear illustrations throughout.

368 pages **Order code NE40** **£29.00**





PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

HOW TO BUILD A COMPUTER
R.A. Penfold

To build your own computer is, actually, quite easy and does not require any special tools or skills. In fact, all that it requires is a screwdriver, pliers and some small spanners rather than a soldering iron! The parts required to build a computer are freely available and relatively inexpensive.

Obviously, a little technical knowledge is needed in order to buy the most suitable components, to connect everything together correctly and to set up the finished PC ready for use. This book will take you step-by-step through all the necessary procedures and is written in an easy to understand way. The latest hardware components are covered as is installing the Windows Vista operating system and troubleshooting.

320 pages **Order code BP592** **£8.99**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

124 pages **Order code PC115** **£5.45**

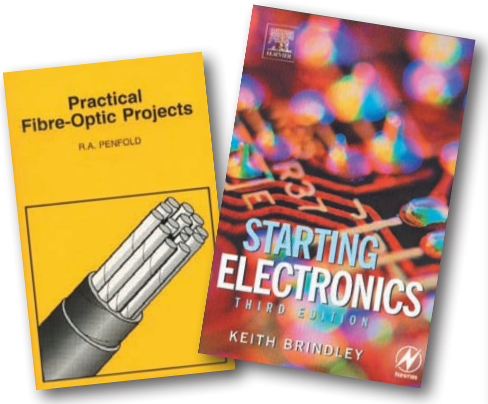
THEORY AND REFERENCE

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£5.49**



STARTING ELECTRONICS
Third Edition
Keith brindley

A punchy practical introduction to self-build electronics. The ideal starting point for home experimenters, technicians and students who want to develop the real hands-on skills of electronics construction.

A highly practical introduction for hobbyists, students, and technicians. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits.

Breadboard layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equiped lab.

288 pages **Order code NE42** **£13.99**

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Back numbers or photocopies of articles are available if required – see the Back Issues page for details. WE DO NOT SUPPLY KITS OR COMPONENTS FOR OUR PROJECTS.

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A large number of older boards are listed on, and can be ordered from, our website.

Boards can only be supplied on a payment with order basis.

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★ PIC Probe (double-sided)	717	£9.50
★ Simple Data-Logging Weather Station		
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NEXT MONTH

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Next month we hit the ground running with this out-of-this-world radio astronomy project! Fancy listening to bursts of noise from planet Jupiter, or the Sun? With this simple shortwave receiver and a basic dipole antenna (also described) you can listen to the solar system through the sound card in your PC, or print out 'chart recordings'.

ULTRA-LD 200W POWER AMPLIFIER – Pt. 2

In the Aug '10 issue we introduced our new Ultra-LD 200W Amplifier module and described the circuit. Next month, we'll give the assembly details and describe a suitable power supply.

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SEPT '10 ISSUE – ON SALE 12 AUGUST

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113 Lynwood Drive, Merley, Wimborne, Dorset BH21 1UU

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EMAIL: epeads@wimborne.co.uk

For Editorial address and phone numbers see page 7

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